Scientific, Technical and Economic Committee for Fisheries (STECF)

Opinion by written procedure

Assessment of Black Sea Stocks (STECF-OWP-11-06)

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SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF)

Assessment of Black Sea Stocks (STECF-OWP-11-04)

NOVEMBER 2011

Request to the STECF

STECF is requested to review the report of the **EWG-11-16** held from October 10 – 14, 2011 in Sofia (Bulgaria), evaluate the findings and make any appropriate comments and recommendations.

Introduction

The report of the Expert Working Group on Assessment of Black Sea Stocks (EWG-11-16) was reviewed by the STECF intersessionally by correspondence. The following observations, conclusions and recommendations represent the outcomes of that review which was adoped by written procedure and released on 3 November, 2011.

STECF observations

STECF notes that the STECF EWG 11-16 attempted analytical stock assessments for sprat, turbot, anchovy, whiting, horse mackerel, piked dogfish and rapa whelk in the Black Sea. Of these, acceptable assessments of stock status and exploitation rate were accomplished for sprat, turbot, anchovy and whiting. F0.1, an appropriate proxy for FMSY consistent with high long term yields and low risk of fishery collapse was also determined for these stocks. The assessment for sprat, anchovy and whiting were considered sufficiently reliable to form the basis of catch forecasts assuming a range of management options, whereas the assessment results for turbot were considered to be indicative of relative changes and could not be used as a basis for catch forecasts.

The results of assessments for piked dogfish and rapa whelk were inconclusive and the assessment for horse mackerel is considered to be indicative of trends only.

STECF conclusions

STECF concludes that the report of the STECF-EWG 11-16 represent the most up-to-date information on the status of fishery resources in the Black Sea. STECF endorses the approach of the EWG and the findings and conclusions in the report.

STECF concludes that while the results of the analytical assessments of sprat, turbot, anchovy and whiting in the Black Sea are imprecise they represent the best estimates available. The imprecision is largely due to data deficiencies resulting from there being no standardised or consistent methodology to raise national landings and/or discards to derive reliable international estimates.

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The results of assessments for piked dogfish and rapa whelk were inconclusive and the assessment for horse mackerel is considered to be indicative of trends only.

1.1 STECF conclusions

STECF concludes that the report of the STECF-EWG 11-16 represent the most reliable up-to-date information on the status of fishery resources in the Black Sea. STECF endorses the approach of the EWG and the findings and conclusions in the report.

STECF concludes that while the results of the analytical assessments of sprat, turbot, anchovy and whiting in the Black Sea are imprecise they represent the best estimates available. The imprecision is largely due to data deficiencies resulting from there being no standardised or consistent methodology to raise national landings and/or discards to derive reliable international estimates.

STECF notes that fishery independent scientific surveys to monitor the living resources in the Black Sea (mortality and recruitment) are either lacking or very limited in area coverage and cover short periods only and concludes that this generally increases the uncertainty in the recent parameters of the stock assessments and the short term predictions of stock size and catch. Accordingly STECF suggests that steps be taken to establish internationally coordinated fishery independent scientific surveys to monitor the living resources across all national waters of the Black Sea.

Stock-specific conclusions

Sprat

STECF concludes that the proposed the exploitation rate E≤0.4 (equals F≤0.64) is an appropriate limit management reference point consistent with high long term yields (Fmsy proxy) for sprat in the Black Sea. Over the last few years the fishing mortality has peaked in 2005 and 2009 at a level of about F=0.59. This equates to an exploitation rate of about E=0.38 (natural mortality M=0.95). Accordingly STECF concludes that stock of sprat in the Black Sea is currently being exploited at a sustainable rate. STECF therefore advises that to maintain the exploitation rate at the current sustainable level, total international catches of sprat from the Black Sea in 2012 should not exceed 100 000 t. The predicted catch of 100,000t at status quo fishing mortality, which represents an approximate 50% increase on the catch advised for 2011 is largely attributable to incoming good recruitment. In the absence of an allocation key for the international sprat catches, STECF is unable to advise a specific EU TAC for sprat in the Black Sea.

Turbot

STECF concludes that F0.1≤0.18 (Fmsy proxy) is an appropriate limit reference point consistent with high long term yields and low risk of fishery collapse for turbot in the Black Sea. Results from both of the assessments for turbot with and without estimates of unreported catches, indicate that fishing mortality has recently been in the range of F=0.6 – F=0.8. Accordingly STECF concludes that significant overfishing of the stock of turbot in the Black Sea is currently taking place. This is despite the low TACs set recently by the EU for Bulgaria and Romania. STECF therefore advises that to achieve the major reduction in fishing mortality on turbot required to achieve a sustainable level, total international catches need to be controlled and reduced to the lowest level possible. In the absence of a reliable quantitative assessment and catch forecast STECF is unable to determine an appropriate catch limit for 2012.

Anchovy

STECF concludes that the proposed exploitation rate E≤0.4 is an appropriate limit reference point consistent with high long term yield and low risk of fisheries collapse for anchovy in the Black Sea. Noting that the assessment results indicate that the current rate of exploitation is above this level, STECF concludes that overfishing of the stock of anchovy in the Black Sea is currently taking place (Current $F_{(1-3)}$=0.62, E≤0.4 = FMSY≤0.41). STECF therefore advises that to achieve the sustainable exploitation rate (E≤0.4) for anchovy in the Black Sea in 2012, total international catches in 2012 should not exceed 200 000 t. In the absence of an allocation key for the international anchovy catches, STECF is unable to advise a specific EU TAC for anchovy in the Black Sea.

Whiting

STECF concludes that the proposed Fmsy(1-4)≤0.4 (proxy derived from F0.1) is an appropriate limit reference point consistent with high long term yields and low risk of fisheries collapse for whiting in the Black Sea. The estimated F(1-4)=0.59 exceeds such reference point and thus STECF concludes that overfishing of the stock of whiting in the Black Sea is currently taking place. STECF therefore advises that to achieve the sustainable exploitation rate (FMSY≤0.4) in 2012, total international catches of whiting from the Black Sea should not exceed 10 000 t. In the absence of an allocation key for the international whiting catches, STECF is unable to advise a specific EU TAC for whiting in the Black Sea.

1.2 STECF recommendations

There are no specific recommendations arising from the STECF review of the STECF-EWG 11-16 Report.

REPORT TO THE STECF

EXPERT WORKING GROUP ON ASSESSMENT OF BLACK SEA STOCKS (EWG-11-16)

Sofia, Bulgaria, 10-14 October 2011

2 EXECUTIVE SUMMARY

In response to the ToR the STECF EWG 11-16 on Black Sea stock assessments has accomplished seven stock assessments approaches of sprat, turbot, anchovy, whiting, horse mackerel, piked dogfish and rapa whelk. Relevant data have been compiled and reviewed, including those called officially by DG Mare through the 2011 DCF data call for the Mediterranean and Black Sea. Expert knowledge complemented the data underlying the stock assessment approaches. The methods and data of the seven stock assessment approaches are documented in section 6 of the present report.

Among the seven stock assessment approaches undertaken, four stock assessments resulted in analytical estimations of the status of stock size and exploitation, i.e. sprat, turbot, anchovy and whiting. For these four stocks biological reference points consistent with high long term yields and low risk of fisheries collapses were determined accepting the estimated F0.1 values as Fmsy approximations. In addition to the detailed assessment sections, the present report provides short summary sheets to describe the stock and fisheries status and provide catch advice as appropriate. While the stock biomass estimates of turbot are considered to reflect relative changes only, the stock assessments of sprat, anchovy and whiting concluded in short term predictions of stock size and catches over a range of management options.

The remaining three stock assessments approaches did not deliver such detailed results and are considered indicative of trends only, i.e. for horse mackerel, or did not provide conclusive results, i.e. piked dogfish and rapa whelk.

3 CONCLUSIONS OF THE WORKING GROUP

The STECF EWG 11-16 notes that the presented analytical assessments of sprat, turbot, anchovy and whiting in the Black Sea are considered imprecise due to various data deficiencies. Yet there are no consistent frameworks developed to aggregate and raise national landings and/or discards to international figures. The assessments provided are based on the best estimates available.

The STECF EWG 11-16 notes that fishery independent scientific surveys to monitor the living resources in the Black Sea (mortality and recruitment) are either lacking or very limited in area coverage and cover short periods only. This lack generally increases the uncertainty in the recent parameters of the stock assessments and the short term predictions of stock size and catch.

The STECF EWG 11-16 proposes the exploitation rate E≤0.4 (equals F≤0.64) as limit management reference point consistent with high long term yields (Fmsy proxy) for sprat in the Black Sea. Over the last few years the fishing mortality has piqued in 2005 and 2009 at a level of about F=0.59. This equals an exploitation rate of about E=0.38 (natural mortality M=0.95). The EWG considers the stock of sprat in the Black Sea as sustainably exploited.

The STECF EWG 11-16 proposes F0.1≤0.18 (Fmsy proxy) as limit reference point consistent with high long term yields and low risk of fishery collapse for turbot in the Black Sea. Both assessment approaches, with and without estimated illegal catches, result in recent high F in the range of 0.6-0.8. The EWG classifies the stock of turbot in the Black Sea as being subject to overfishing. The EWG notes that despite the recently low TACs in the European EEZs of Bulgaria and Romania the fishing mortality remains at a high level (above three times the sustainable level) with no signal of reduction.

The STECF EWG-11-16 proposes the exploitation rate E≤0.4 as limit reference point consistent with high long term yield and low risk of fisheries collapse for anchovy in the Black Sea. The EWG classifies the stock as being subject to overfishing as the estimated F(1-3)=0.62 exceeds such exploitation rate E≤0.4 which equals Fmsy(1-3)=0.41 (proxy derived from F0.1).

The STECF EWG 11-16 proposes $F_{msy}(1\text{-}4) \leq 0.4$ (proxy derived from F0.1) as limit reference point consistent with high long term yields and low risk of fisheries collapse. The estimated $F(1\text{-}4)=0.59$ exceeds such reference point and thus the EWG 11-16 classifies the stock of whiting in the Black Sea as being subject to overfishing.

4 RECOMMENDATIONS OF THE WORKING GROUP

The STECF EWG 11-16 recommends the establishment of fishery independent scientific surveys to monitor the living resources across all national waters of the Black Sea be established including Bulgaria, Romania, Georgia, Russia, Turkey and Ukraine.

The STECF EWG 11-16 recommends a sustainable status quo exploitation for sprat in the Black Sea in 2012 which implies catches of 100 000 t not to be exceeded in 2012. In the absence of an allocation key for the international sprat catches, EWG 11-16 is unable to advice on a specific EU TAC for sprat in the Black Sea.

The STECF EWG 11-16 recommends the catches of turbot in the Black Sea being reduced to the lowest possible level.

The STECF EWG-11-16 recommends the exploitation of anchovy in the Black Sea to be sustainable in 2012 and the catch in 2012 not to exceed 200 000 t. In the absence of an allocation key for the international anchovy catches, EWG 11-16 is unable to advice on a specific EU TAC for anchovy in the Black Sea.

The EWG-11-16 recommends the exploitation of whiting in the Black Sea to be sustainable in 2012 and the catch in 2012 not to exceed 10 000 t. In the absence of an allocation key for the international whiting catches, EWG 11-16 is unable to advice on a specific EU TAC for whiting in the Black Sea.

5 INTRODUCTION

The STECF Expert Working Group EWG 11-16 meeting was held during 10-14 October 2011 at the Hotel Arena di Serdica in Sofia, Bulgaria. The chairman called the group to order by 9 am on 10 October 2011, and adjourned the meeting by 4 pm on 14 October 2011. The meeting was attended by 13 experts from Bulgaria (4), Romania (2), Sweden (1), Turkey (4), Ukraine (2).

The present report of the EWG 11-16 is divided into two main parts. The first part presents short summary sheets of stock assessment results and respective scientific advice. Such summary sheet are provided if the expert working group succeeded to agree on analytical assessments of stock and fisheries parameters and biological reference points consistent with high long term yields and low risks of fisheries collapses. In such cases, the status of the stocks is assessed against such biological reference points and respective fisheries management advice is provided. The second part presents all the details of the stock and fisheries assessments undertaken by the group of experts, fully documented data and data reviews as well as assessment methods applied.

5.1 Terms of Reference for EWG-11-16

Background: The European Union adopted for the first time in 2008 and then for subsequent years catch limitations and associated technical measures for sprat and turbot fisheries in the Black Sea. Those measures were adopted in the light of scientific advice provided by STECF.

Last year, the STECF sub-group on resources status (SGRST) met in Cadiz (Spain) with the objective, among others, of assessing the state of the main stocks in the Black Sea Region. As an outcome of this meeting, STECF provided stock summary sheets for turbot and sprat, based on the available information. In these summary sheets STECF underlines that, despite substantial progress in the analytical assessment of sprat and turbot, there is still a considerable level of uncertainty for turbot that can only be improved if reliable catch statistics from all countries are available.

For other relevant stocks (anchovy, whiting, Mediterranean horse-mackerel, Picked dogfish and Rape Whelk), STECF was not in the position of providing scientific advice

With a view to improve and update the assessments and catch forecast of the concerned stocks and fisheries in the area as well as assess the need for the establishment of further management measures for fish stocks in the Black Sea, STECF is requested to provide scientific advice on the present status and recent development of stocks and the marine ecosystem of the Black Sea and evaluate the existing measures.

It is particularly appreciated the participation in STECF work of scientists from non-EU countries (Turkey, Ukraine and Russian Federation), that will allow a strengthen cooperation namely for the assessment of shared stocks.

The outcomes of this Expert Working Group meeting will certainly provide valuable information as a basis for further joint analysis and discussions that will be held in the First meeting of the GFCM ad-hoc Working Group on the Black Sea to be held in Romania from 16 to 18 January 2012.

This is another step toward a deeper cooperation on fisheries related matters amongst Black Sea scientists which will help feeding coastal states' reflections on the direction ahead to improve fisheries management and governance at multilateral level in the Black Sea Region.

> ***<u>NB:</u>*** *When assessing stocks distributed in the Black Sea, STECF will be requested to check and report possible problems encountered regarding access to relevant data, data quality and completeness of data.*

Terms of reference:

Without prejudice, STECF is requested to advice in particular on 2012 catch forecasts compatible with high yields and lower risk of stock depletion as well as on the state of the most relevant exploited stocks with a view to inform management choices, including technical measures, in line with EU policy objectives and principles for sustainable fisheries management for the stocks listed in Annex I.

EWG 11-16 is requested to address the following ToR for Black Sea stocks:

- Compile and provide complete sets of national annual data on landings, discards, landings at age, discards at age, mean weight at age in the landings, mean weight at age in the discards, maturity ogives at age and natural mortality at age by area for the longest time series available up to and including 2010. The data should be compiled based on official data bases, best expert knowledge and by using the results of scientific surveys.

- Compile and provide all fishery independent data (pelagic, demersal, hydro-acoustic surveys) for the stocks as available, their juveniles, eggs or early life stages. In order to allow the use of such data to potentially calibrate virtual population analyses, the abundance, biomass and spawning stock biomass indices at age should be compiled for the longest time series available up to and including 2010.

- Compile and provide complete sets of annual fishing effort data (number of vessels, kW*days, GT*days, fished hours) by nation, for fleets and gears (by mesh size where applicable), and area for the longest time series available up to and including 2010.

- Assess trends in historic stock parameters for the longest time series available up to and including 2010 (fishing mortality at age) and up to and including 2010 (spawning stock biomass, stock biomass, recruits at age). Different assessment models should be applied as appropriate, including analyses of retrospective effects.

- Propose and evaluate candidate limit and precautionary reference points consistent with maximum sustainable yield and precautionary approach;

- Review and evaluate existing fisheries management measures and comment about their adequacy to ensure sustainable exploitation of stocks while delivering higher yields and low risk of stock depletion;

- Predict spawning stock biomass, stock biomass, recruits and catches at age and in weight in, 2011, 2012 and the beginning of 2013 under different management scenarios including the status quo fishing (mean F at age 2008-2010, rescaled to 2010) and with a TAC constraint for 2011. Specifically comment on the consequences for the listed stock parameters with regard to reference points consistent with maximum sustainable yield;

- Up-date the description of EU fisheries exploiting these stocks, in terms of fleets, fishing gears, deployed fishing effort (capacity in N°-GT-kW, activity in days at sea, gear characteristics), catches and catch composition, size composition, discards, fishing grounds and seasonality;

- Identify knowledge and monitoring gaps for fisheries, stocks, vital fish habitats and other environmental aspects relevant to fisheries in the area and provide information on the reasons for this deficiency and suggest monitoring and scientific actions that need to be developed in the short and mid-term to fill these gaps;

- Evaluate the progress made in addressing such gaps since last year;

- Prepare and/or up-date maps showing geographic density patterns in annual abundance indices derived from surveys aggregated for age groups selected by the fisheries and compare them with maps of geographical distribution patterns in annual landings and discards of the stocks listed in Annx I by fishing gear;

- Identify other important fisheries and stocks that may be in need of specific management measures to ensure sustainable exploitation and analyze whether the scientific basis is adequate or needs to be further developed;

- Report all results to the STECF Plenary in November 2011.

In support of its advice STECF shall provide for each stock:

a) A full methodological description of the assessment and advisory procedure updated whenever a significant change is made;

b) Estimates of landings, fishing mortality, recruitment and spawning stock together with information or estimates of the uncertainty with which these parameters are estimated;

List of stocks to be assessed

Species common name	**Species scientific name**	**FAO CODE**
Sprat	*Sprattus sprattus*	SPR
Turbot	*Psetta maxima*	TUR
Whiting	*Merlangius merlangus*	WHG
Anchovy	*Engraulis encrasicolus*	ANE
Mediterranean horse mackerel	*Trachurus mediterraneus*	HMM
Piked dogfish	*Squalus acanthias*	DGS
Rapa Whelk	*Rapana venosa*	RPW

5.2 Participants

The full list of participants at EWG-11-16 is presented in Appendix 1. Antonio Cervantes from DG Mare attended all sessions of the Working Group.

6 SUMMARY SHEETS

The stock specific summary sheets in the following section provide short summaries and scientific advice on stock status and fisheries management. Such short summaries are provided in the case that the detailed assessments succeeded an analytical assessment of the stock status and biological reference points. The full description of data and methods can be found in section 6 of the detailed assessments.

6.1 Summary sheet of sprat (*Sprattus sprattus*) in GSA 29

Species common name:	Sprat
Species scientific name	*Sprattus sprattus*
Geographical Sub-area(s) GSA(s):	GSA 29

Most recent state of the stock

- State of the adult abundance and biomass (SSB):

According to the present assessment the SSB ranges at medium to high levels: in the range of 300 - 400 000 t in recent years. Under a constant recruitment scenario and status quo F, SSB is expected to stay at the approximate same level by 2013. Since no precautionary level for the stock size of sprat in GSA 29 was proposed, EWG 11-16 cannot fully evaluate the stock status in relation to the precautionary approach. However, the stock appeared to increase recently.

- State of the juveniles (recruits):

Recruitment estimates since 2007 are estimated to range at a high level as compared with a long term trend. Such estimates are considered rather imprecise due to the lack of survey data.

- State of exploitation:

EWG 11-16 proposes the exploitation rate E ≤0.4 (=F≤0.64) as limit management reference point consistent with high long term yields (F_{MSY} proxy). Over the last few years the fishing mortality has piqued in 2005 and 2009 at a level of about F=0.59. This equals an exploitation rate of about E=0.38 (natural mortality M=0.95). The EWG considers the stock of sprat in the Black Sea as sustainably exploited.

- Source of data and methods:

International landings data at age were constructed and the Integrated Catch Analyses (ICA) is applied. Discards are believed to be low. Short term prediction is provided based on a short term geometric average recruitment.

Outlook and management advice

EWG 11-16 classifies the stock as being sustainably exploited close to the biological reference point of E≤0.4 consistent with high long term yields. EWG 11-16 recommends a sustainable status quo exploitation for 2012 which implies catches of 100 000 t not to be exceeded in 2012. In the absence of an allocation key for the international sprat catches, EWG 11-16 is unable to advice on a specific EU TAC for sprat in the Black Sea.

Short and medium term scenarios:

A short term prediction of stock size and catches assuming a sustainable status quo fishing scenario has been provided together with a range of management options. Considering the short life span of sprat in the Black Sea and the high variation in estimated recruitment, EWG 11-16 emphasises that the short term projections based on a geometric mean recruitment and the resulting catch advice are subject to high uncertainty. The poor knowledge about the recruitment dynamics prevented the formulation of medium term projections.

Fisheries

The following table list the landings (tons) by nation.

	Bulgaria	*Bulgaria	Romania	Ukraine	Turkey	Turkey*	Georgia	Russian Federation	Total
1970	1407		2678	353	0		0		4438
1971	2473		2517	846	0		0		5836
1972	2962		23	884	0		0	16	3885
1973	3383		22	878	0		0	22	4305
1974	4468		1245	477	0		0	23	6213
1975	5565		731	787	0		0	43	7126
1976	7199		161	1594	0		0	16	8970
1977	8754		1463	4346	0		0	2354	16917
1978	10596		149	1949	0		1	3317	16012
1979	13541		2269	36757	0		3466	17700	73733
1980	16568		989	47635	0		4571	14687	84450
1981	1888		2283	49175	0		5781	20165	79292
1982	16524		3004	3862	0		2462	15266	41118
1983	12023		3406	20755	0		886	3843	40913
1984	13921		4456	18021	0		847	5270	42515
1985	15924		6836	23657	0		1817	3365	51599
1986	1169		8979	33147	0		2939	7010	53244
1987	10979		9474	43158	0		697	8972	73280
1988	6199		6454	39835	0		7172	7157	66817
1989	7403		8911	63239	0		9708	16045	105306
1990	2651		3198	33174	0		6895	6955	52873
1991	1909		729	11094	0		2313	2675	17082
1992	2353	3266	2074	11492	0		830	3221	20883
1993	2174	3705	2439	9154	640		32	694	16664
1994	2200	3500	2203	12615	700		308	1013	20339
1995	2874	3200	1982	15218	157		288	1263	22108
1996	3535	3500	2014	20720	937		185	1537	28893
1997	3646	3646	3318	20208	468		85	706	28431
1998	3275	3275	3293	30282	1236		24	1243	39353
1999	3595	3595	1933	29238	421		45	4473	39705
2000	1737	3500	1803	32644	6225		42	5543	49757
2001	695	6961	1792	48938	1008		40	11122	69861
2002	11595	11595	1617	45430	1965		34	11218	71859
2003	9155	9155	1219	31366	5775		2	204	47721
2004	2889	7997	135	30891	5186		12	143	44364
2005	2575	6500	1487	35707	5271		19	1316	50300
2006	2655	8183	492	21308	6681			8157	44821
2007	2559	2985	208	18013	11725			6077	39008
2008	4304	4304	234	21111	39903			7814	73366
2009	4551	4551	92	24603	53385			8744	91375
2010	4041	4041	39	24652	57023			5800	91555

*some landings are based on expert jugement

Limit and precautionary management reference points

Table of limit and precautionary management reference points proposed by STECF EWG 11-16

E (mean)	≤ 0.4

Table of limit and precautionary management reference points agreed by fisheries managers

F_{msy} (age range)=	none
B_{pa} (B_{lim}, spawning stock)=	none

Comments on the assessment

The detailed assessment of sprat in GSA 29 can be found in the following section 6. EWG 11-16 recommends an international hydro-acoustic survey to monitor the sprat across all national waters of the Black Sea be established including Bulgaria, Romania, Georgia, Russia, Turkey and Ukraine.

6.2 Summary sheet of turbot (*Scophthalmus maximus*) in GSA 29

Species common name:	Turbot
Species scientific name	*Scophthalmus maximus*
Geographical Sub-area(s) GSA(s):	GSA 29

Most recent state of the stock

- State of the adult abundance and biomass (SSB):

Relative stock size indices from surveys and two XSA estimations indicate that the stock is at a historic low which significantly increases the risk of fisheries collapse. Since no precautionary level for the stock size of sprat in GSA 29 was proposed, EWG 11-16 cannot fully evaluate the stock status in relation to the precautionary approach.

- State of the juveniles (recruits):

Recruitment has increased since 2003 but this has not yet materialized in a significant increase in SSB.

- State of exploitation:

The STECF EWG 11-16 has proposed Fmsy≤0.18 as limit reference point consistent with high long term yields and low risk of fisheries collapses. Both assessment approaches, with and without estimated illegal catches, result in recent high F in the range of 0.6-0.8. The EWG classifies the stock of turbot in the Black Sea as being subject to overfishing.

- Source of data and methods:

International landings data at age are believed to be underestimated due to illegal catches, discards are considered negligible. XSA analyses tuned by short bottom trawl survey with a very restricted area coverage is applied. No short term prediction is provided due to uncertain catch figures.

Outlook and management advice

EWG 11-16 recommends the catches being reduced to the lowest possible level. The EWG notes that despite the recently low TACs in the European EEZs of Bulgaria and Romania the fishing mortality remains at a high level (above three times the sustainable level) with no signal of reduction.

Short and medium term scenarios:

Uncertainty about catch figures prevented a precise stock assessment which could provide the basis for short and medium term projections of stock size and catches.

Fisheries

The following table list the landings (tons) by nation.

Year	Bulgaria	Romania	Ukraine west	Ukraine east	Turkey west	Turkey east	Russian Federation	Georgia	Black Sea total	Black Sea west
1989	0.9	0	2	0	448	1001	0	8	1459.9	450.9
1990	0	0	9	0	908	475	0	1	1393	917
1991	0	2	17.1	0.9	600	315	0	0	935	619
1992	0	1	18	1	308	110	1	0	439	327
1993	0	6	10	0	400	1185	2	0	1603	416
1994	0	6	18	1	1293	821	5	0	2144	1317
1995	60	4	10	0	2006	844	19	0	2943	2080
1996	62	6	37	2	1414	510	17	0	2048	1519
1997	60	1	40	2	777	134	11	0	1025	878
1998	64	0	40	2	1056	412	14	0	1588	1160
1999	54	2	69	4	1579	225	15	5	1953	1704
2000	55.1	2	76	4	2321	318	4	9	2789.1	2454.1
2001	56.5	13	123	6	2169	154	24	11	2556.5	2361.5
2002	135.5	16.681	99	5.47	193	142	15	11	617.651	444.5
2003	40.8	23.978	118	5.876	126	93	15	1	423.654	308.8
2004	16.2	42.031	126	7.157	118	116	1.7	7	434.088	302.2
2005	12.69	36.53	123	6	273	275	7.5	7	740.72	445.69
2006	14.81	35.108	154	8	266	481	7.6	0	966.518	466.81
2007	66.852	48.064	205	10.58	346	353	5.7	0	1035.396	666
2008	54.621	47.112	239	12.35	224	234	4.7	0	815.786	565
2009	52.47	48.767	247	16	223	119	24.3	0	730.537	571
2010	46.45	48.25	166.00	41.00	218.00	77.00	25	0	621.70	479

Limit and precautionary management reference points

Table of limit and precautionary management reference points proposed by STECF EWG 11-16

Fmsy	≤ 0.18

Table of limit and precautionary management reference points agreed by fisheries managers

F_{msy} (age range)=	none
B_{pa} (B_{lim}, spawning stock)=	none

Comments on the assessment

The detailed assessment of turbot in GSA 29 can be found in the following section 6. EWG 11-16 recommends an international bottom trawl survey to monitor the turbot across all national waters of the Black Sea be established including Bulgaria, Romania, Georgia, Russia, Turkey and Ukraine.

6.3 Summary sheet of anchovy (*Engraulis encrasicolus*) in GSA 29

Species common name:	Anchovy
Species scientific name	*Engraulis encrasicolus*
Geographical Sub-area(s) GSA(s):	GSA 29

Most recent state of the stock

- State of the adult abundance and biomass (SSB):

Following some drastic changes in stock size, the SSB is indicated to have remained rather stable around 800 000 t since 2007. Since no precautionary level for the stock size of anchovy in GSA 29 was proposed, EWG 11-16 cannot fully evaluate the stock status in relation to the precautionary approach.

- State of the juveniles (recruits):

During the period 2002 to 2009 the recruitment has varied without a clear trend.

- State of exploitation:

STECF EWG-11-16 proposes $E \leq 0.4$ as limit reference point consistent with high long term yield and low risk of fisheries collapses. The EWG classifies the stock as being subject to overfishing as the estimated $F_{(1-3)}=0.62$ exceeds such exploitation rate $E \leq 0.4$, which equals $Fmsy_{(1-3)}=0.41$, assuming an $M_{(1-3)}=0.62$.
The EWG-11-16 recommends the exploitation of anchovy to be sustainable and the catch in 2012 not to exceed 200 000 t.

- Source of data and methods:

International landings at data at age were constructed while discards are considered negligible. XSA analyses tuned by a single commercial CPUE of the major Turkish purse seiner fishery is applied. Short term prediction is provided based on short term geometric mean recruitment.

Outlook and management advice

The EWG-11-16 recommends the exploitation of anchovy to be sustainable and the catch in 2012 not to exceed 200 000 t. Considering the short life span of anchovy in the Black Sea and the high variation in estimated recruitment, EWG 11-16 emphasises that the short term projections based on a geometric mean recruitment are subject to high uncertainty. In the absence of an allocation key for the international anchovy catches, EWG 11-16 is unable to advice on a specific EU TAC for anchovy in the Black Sea.

Short and medium term scenarios:

A short term prediction of stock size and catches assuming a sustainable status quo fishing scenario has been provided together with a range of management options. Considering the short life span of anchovy in the Black Sea and the high variation in estimated recruitment, EWG 11-16 emphasises that the short term projections based on a geometric mean recruitment and the resulting catch advice are subject to high uncertainty. The poor knowledge about the recruitment dynamics prevented the formulation of medium term projections.

Fisheries

The following table list the landings (tons) by nation.

Year	Bulgaria	Georgia	Romania	Russian Federation	Turkey	Ukraine	Un. Sov. Soc. Rep.
1970	90	.	2261	.	71506	.	117800
1971	126	.	3791	.	70400	.	126700
1972	156	.	3200	.	91675	.	111000
1973	264	.	1400	.	86998	.	132500
1974	41	.	855	.	75728	.	227900
1975	15	.	592	.	59142	.	173626
1976	72	.	2749	.	67992	.	236234
1977	113	.	1646	.	71366	.	152607
1978	37	.	2746	.	105184	.	134855
1979	307	.	2251	.	133678	.	126763
1980	209	.	6431	.	239289	.	165900
1981	70	.	4942	.	259767	.	153272
1982	266	.	4294	.	266523	.	175100
1983	784	.	5532	.	289860	.	200630
1984	239	.	6354	.	318917	.	240640
1985	92	.	2414	.	273274	.	110200
1986	96	.	2510	.	274740	.	191370
1987	13	.	1447	.	295902	.	66241
1988	115	97452	3171	64852	295000	65872	-
1989	.	32401	61	16426	96806	15536	-
1990	.	4656	5	6780	66409	17392	-
1991	.	5643	46	42	79225	1796	-
1992	.	6871	85	7294	155417	11507	-
1993	.	1656	374	2137	218866	8698	-
1994	.	857	197	4600	278667	14500	-
1995	35	1301	189	10071	373782	15516	-
1996	23	1232	138	2954	273239	2898	-
1997	44	2288	45	3283	213780	7695	-
1998	48	2346	146	2465	195996	3367	-
1999	36	1264	155	2268	310801	5188	-
2000	64	1487	204	5292	260670	11720	-
2001	102	941	186	7766	288616	11953	-
2002	237	927	296	9271	336419	10450	-
2003	131	2665	160	7999	266069	12169	-
2004	88	2562	135	7323	306656	5947	-
2005	14	2600	154	6706	119255	6380	-
2006	6.464	9222	11	3925	212081	7090	-
2007	60.44	17447	35	4900	357089	4573	
2008	27.666	25938	15	9500	225334	4298	
2009	42.41		21	9927	185606	8024	
2010	65		50		203026	5051	

Limit and precautionary management reference points

Table of limit and precautionary management reference points proposed by STECF EWG 11-16

E=0.4 equals Fmsy(1-3)	≤ 0.41

Table of limit and precautionary management reference points agreed by fisheries managers

F_{msy} (age range)=	none
B_{pa} (B_{lim}, spawning stock)=	none

Comments on the assessment

The detailed assessment of anchovy in GSA 29 can be found in the following section 6. EWG 11-16 recommends an international hydro-acoustic survey to monitor the anchovy across all national waters of the Black Sea be established including Bulgaria, Romania, Georgia, Russia, Turkey and Ukraine.

6.4 Summary sheet of whiting (*Merlangius merlangus*) in GSA 29

Species common name:	Whiting
Species scientific name	*Merlangius merlangus*
Geographical Sub-area(s) GSA(s):	GSA 29

Most recent state of the stock

- State of the adult abundance and biomass (SSB):

Since 1994 the SSB has varied without a trend. In the absence of biological reference points the EWG 11-16 is unable to fully evaluate the stock status with regard to the precautionary approach.

- State of the juveniles (recruits):

Since 1994 the recruitment has varied without a trend. There is no fishery indepent recruitment index (survey) available as none of the surveys cover the entire stock area.

- State of exploitation:

The EWG 11-16 proposes Fmsy(1-4)≤0.4 (approximation based on F0.1 estiamte) as limit reference point consistent with high long term yields and low risk of fisheries collapse. As the estimated F(1-4)=0.59 exceeds such reference point and thus the EWG 11-16 classifies the stock of whiting in the Black Sea as being subject to overfishing.

- Source of data and methods:

International landings at data at age were constructed while discards are considered negligible. XSA analyses tuned by a short (3 years) single survey (Romanian bottom trawl) with a limited area coverage is applied. Short term prediction is provided based on short term geometric mean recruitment.

Outlook and management advice

The EWG-11-16 recommends the exploitation of whiting to be sustainable and the catch in 2012 not to exceed 8500 t. In the absence of an allocation key for the international whiting catches, EWG 11-16 is unable to advice on a specific EU TAC for whiting in the Black Sea.

Short and medium term scenarios:

A short term prediction of stock size and catches assuming a sustainable status quo fishing scenario in 2011 has been provided together with a range of management options. Considering the short life span of whiting in the Black Sea and the high variation in estimated recruitment, EWG 11-16 emphasises that the short term projections based on a geometric mean recruitment and the resulting catch advice are subject to high uncertainty. The poor knowledge about the recruitment dynamics and lack of discard estimates in the catch statistics prevented the formulation of medium term projections.

Fisheries

The following table list the landings (tons) by nation.

Year	Bulgaria	Georgia	Romania	Russian Federation	Turkey	Ukraine	Un. Sov. Soc. Rep.
1970	-	.	115	.	4312	.	.
1971	-	.	442	.	5855	.	-
1972	-	.	416	.	5284	.	-
1973	-	.	329	.	2476	.	-
1974	-	.	1305	.	2844	.	-
1975	454	.	346	.	3913	.	-
1976	347	.	541	.	4213	.	-
1977	218	.	1495	.	5726	.	-
1978	407	.	1345	.	21265	.	531
1979	71	.	1205	.	20778	.	11377
1980	30	.	618	.	6838	.	2690
1981	1	.	894	.	4669	.	2238
1982	4	.	800	.	4264	.	1513
1983	-	.	1080	.	11696	.	2381
1984	-	.	1192	.	11595	.	4738
1985	-	.	3138	.	16036	.	2655
1986	-	.	1949	.	17738		2652
1987	-	.	615	.	27103		2764
1988	-	5	1009	736	28263	1482	-
1989	-	5	2738	7	19283	579	-
1990	-	-	2653	235	16259	87	-
1991	-	-	59	-	18956	24	-
1992	-	70	1357	-	17923	.	-
1993	-	172	599	16	17844	5	-
1994	-	187	432	125	15084	64	-
1995	-	146	327	91	17562	17	-
1996	-	223	372	11	20326	3	-
1997	-	58	441	10	12725	29	-
1998	-	53	640	119	11863	55	-
1999	-	41	272	184	12459	18	-
2000	9	.	275	341	15343	20	-
2001	8	32	306	642	7781	18	-
2002	16	37	85	656	7775	9	-
2003	13	45	113	93	7062	21	-
2004	2	29	118	55	7243	43	-
2005	3	30	92	78	6637	30	-
2006	0.5	37	113	60	7797	15	
2007	16.114	41	118	22	11232	64	
2008	0.44	15	92	96	10986	9	
2009	2.27		1	52	15905	17	

Limit and precautionary management reference points

Table of limit and precautionary management reference points proposed by STECF EWG 11-16

Fmsy(1-3) proxy derived from F0.1	$\leq$ 0.40

Table of limit and precautionary management reference points agreed by fisheries managers

F_{msy} (age range)=	none
B_{pa} (B_{lim}, spawning stock)=	none

Comments on the assessment

The detailed assessment of whiting in GSA 29 can be found in the following section 6. EWG 11-16 recommends an international hydro-acoustic survey to monitor the whiting across all national waters of the Black Sea be established including Bulgaria, Romania, Georgia, Russia, Turkey and Ukraine, in particular to provide a representative recruitment index. The assessment does not include discards and thus might be biased.

7 DETAILED ASSESSMENTS

7.1 Sprat in the Black Sea

7.1.1 Biological features

7.1.1.1 Stock Identification

The Black Sea sprat (*Sprattus sprattus L.*) is a key species in the Black Sea ecosystem. Sprat is a marine pelagic schooling species, sometimes entering in the estuaries (especially as juveniles) and the Azov Sea and tolerating salinities as low as 4‰. In the daytime, it keeps to deeper water and in the night moves near the surface. It forms big schools and undertakes seasonal movements between foraging (inshore) and spawning (open sea) areas (Ivanov and Beverton 1985). Adults tend to remain under the seasonal thermocline, penetrating above its only during the spring and autumn homothermia. Juveniles are distributed in a larger area near the surface. Sexual maturity is attained at the age of 1 year and length of 7 cm. In Turkey it was found that males reached maturity at 7.5 cm and females at 7.8 cm at age 1 year (Avşar & Bingel, 1994).

Sprat is one of the most important fish species, being fished and consumed traditionally in the Black Sea countries. It is most abundant small pelagic fish species in the region, together with anchovy and horse mackerel and accounts for most of the landings in the north-western part of the Black Sea. Whiting is also taken as a by-catch in the sprat fishery, although there is no targeted fishery beyond this (Raykov, 2006) except for Turkish waters.

Sprat fishing takes place on the continental shelf on 15-110 m of depth (Shlyakhov, Shlyakhova, 2011). The harvesting of the Black Sea sprat is conducted during the day time when its aggregations become denser and are successfully fished with trawls. The main fishing gears are mid-water otter trawl, pelagic pair trawls and uncovered pound nets.

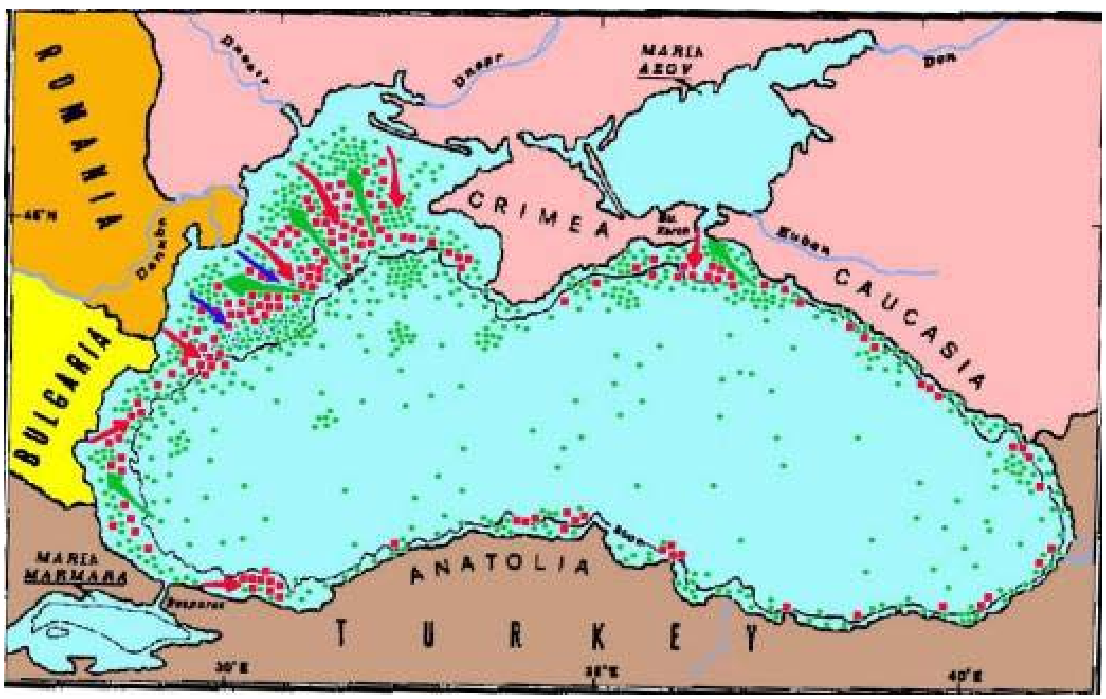


Figure 6.1.1.1.1. Sprat distribution and migration in the Black Sea

Legend: Wintering areas and migration to | Spawning areas and migration to them | Feeding areas and migration to them

7.1.1.2 Growth

The species is fast growing; age comprises 4-5 age groups. The von Bertlanffy Growth Parameters VBGF by countries are given in Table 6.1.1.2.1. In Romanian waters asymptotic length and growth rate is comparable with the growth parameters derived in Bulgarian and Ukrainian Black Sea waters (Table 6.1.1.2.1.).

Table 6.1.1.2.1 VBGF parameters calculated in the Black Sea

	L∞	**k**	**t_0**	**a**	**b**
Bulgaria	12.57	0.82	-0.662	0.0009	2.8811
Romania	12.63	0.533	-1.565	0.0089	2.8121
Ukraine	12.42	0.286	-1.504	0.008475	2.9691
Turkey	14.23	0.14	-3.27	0.05	3.065

Sprat has lengths comprised between 50 and 120 mm, the highest frequency pertaining to the individuals of 70-100 mm lengths. The age corresponding to these lengths was 0+ - 4-4+, the ages 2-2+ - 3-3+ having a significant participation. By 1982, the age classes 4-4+ years had a share of 34% from the catch of this species, then the percentage continually decreased up to 1995 when this age was not signalled, meaning the increase of the pressure through fishing exerted on the populations. While the share of this age decreased, the prevalence of 0+ especially 1-1+ ages became increased. During last years the age structure show the presence of the specimens of 1-1$^+$ and 3; 3$^+$ years, the catch base being the individuals of 1-1$^+$ and 2-2$^+$ years.

Figure 6.1.1.2.1. displays the length distribution of sprat in western Black Sea from commercial catches in 2010.

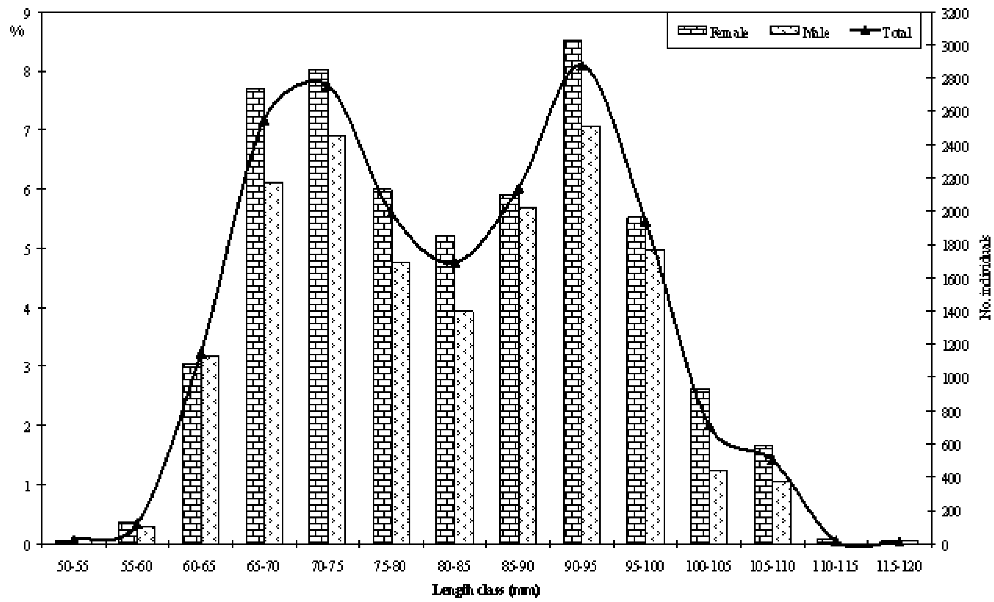


Figure 6.1.1.2.1. Length distributions of sprat (%, No.of individuals) in the catch from the western Black Sea

7.1.1.3 Maturity

The analysis of the gonad maturation (Table 6.1.1.3.1) shows that the majority of specimens were in the VI-II and II degree of maturation during fishing season. Peak of spawning activity take place in December-February.

Table 6.1.1.3.1 Maturity of sprat.

Year	Month	Sex	DEGREE OF MATURATION			
			II	II-III	III	VI-II
2010	IV	F	85.14			14.86
		M	79.47			20.3
	V	F	81.32		11.39	7.29
		M	79.21		17.34	3.44
	VI	F	85.35		14.65	8.86
		M	74.29		25.71	
	VII	F	74.71		52.57	
		M	75.08		24.92	
	VIII	F				
		M				
	IX	F				
		M				
	X	F				
		M				
	XI	F	17.79		52.57	
		M	13.55	49	37.44	

7.1.2 Fisheries

7.1.2.1 General description

The sprat fishery is taking place in the Black Sea (GFCM Fishing Sub-area 37.4 (Division 37.4.2) and Geographical Sub-area (GSA) 29). The opportunities of marine fishing are limited by the specific characteristics of the Black Sea. The exploitation of the fish recourses is limited in the shelf area. The water below 100-150 m is anoxic and contains hydrogen sulphide. In Bulgarian, Romanian, Russian and Ukrainian waters the most intensive fisheries of Black Sea sprat is conducted in April till October with mid-water trawls on vessels 15- 40 m long and a small number vessels >40m. Beyond the 12-mile zone a special permission is needed for fishing. Harvesting of Black Sea sprat is conducted during the day, when the sprat aggregations become denser and are successfully fished with mid-water trawls.

The significance of the sprat fishery in Turkey in the last three years has increased and the landings reached 57 023 t in 2010. The main gears used for sprat fishery in Turkey (fishing area is constrained in front of the city of Samsun) are pelagic pair trawls working in spring at 20-40m depth and in autumn - in deeper water: 40-80m depths.

7.1.2.2 Management regulations applicable in 2010 and 2011

A quota is allocated in EU waters of the Black Sea (Bulgaria and Romania). No fishery management agreement exists between other Black Sea countries. In the EU Black Sea waters a global (both Romania and Bulgaria) TAC 12 750 tons has been allocated in 2009 and 2010. This figure is a result of a reduction of the 2008 TAC of 15 000 t based on the precautionary principle. Ukraine and Russian Federation also apply TAC in their national waters (Table 6.1.4.2.1). Minimum landing size of sprat is applied across the region except in Turkish waters (Table 6.1.4.2.2.).

Table 6.1.4.2.1. Sprat TAC applied in Ukraine and Russian Federation in tons.

Year	**Russian Federation**	**Ukraine**
2005	42 000	60 000
2006		70 000
2007		40 000
2008	21 000	50 000
2009	21 000	50 000
2010	21 000	50 000
2011		60 000

Table 6.1.4.2.2. Minimum landing size of sprat in the Black sea region

	BG	**GE**	**RO**	**RU**	**TR**	**UA**
Sprattus						

sparttus	TL=7cm	SL=6cm	TL=7cm	SL= 6cm	NO	SL=6cm

7.1.2.3 Catches

7.1.2.3.1 Landings

Catch and landings of the sprat in the Black Sea were reported by the Black Sea countries and data from Bulgaria and Romania were collected and reported for the Data Collection Program from National agencies for fisheries and aquaculture in both countries. Mid-water trawl catches dominate the landings.

Landings significantly increased in the last years due to intensification of the sprat fishery in Turkey (but also a gradual increase is reported by Bulgaria, Russia, and Ukraine). Romanian catches decreased to 39 tons in 2010 (Tab. 6.1.2.3.1.1).

Table 6.1.2.3.1.1. Sprat landings in the Black Sea.

	Bulgaria	***Bulgaria**	**Romania**	**Ukraine**	**Turkey**	**Georgia**	**Russian Federation**	**Total**
1970	1407		2678	353	0	0		4438
1971	2473		2517	846	0	0		5836
1972	2962		23	884	0	0	16	3885
1973	3383		22	878	0	0	22	4305
1974	4468		1245	477	0	0	23	6213
1975	5565		731	787	0	0	43	7126
1976	7199		161	1594	0	0	16	8970
1977	8754		1463	4346	0	0	2354	16917
1978	10596		149	1949	0	1	3317	16012
1979	13541		2269	36757	0	3466	17700	73733
1980	16568		989	47635	0	4571	14687	84450
1981	1888		2283	49175	0	5781	20165	79292
1982	16524		3004	3862	0	2462	15266	41118
1983	12023		3406	20755	0	886	3843	40913
1984	13921		4456	18021	0	847	5270	42515
1985	15924		6836	23657	0	1817	3365	51599
1986	1169		8979	33147	0	2939	7010	53244
1987	10979		9474	43158	0	697	8972	73280
1988	6199		6454	39835	0	7172	7157	66817
1989	7403		8911	63239	0	9708	16045	105306
1990	2651		3198	33174	0	6895	6955	52873
1991	1909		729	11094	0	2313	2675	17082
1992	2353	3266	2074	11492	0	830	3221	20883
1993	2174	3705	2439	9154	640	32	694	16664
1994	2200	3500	2203	12615	700	308	1013	20339
1995	2874	3200	1982	15218	157	288	1263	22108
1996	3535	3500	2014	20720	937	185	1537	28893
1997	3646	3646	3318	20208	468	85	706	28431
1998	3275	3275	3293	30282	1236	24	1243	39353
1999	3595	3595	1933	29238	421	45	4473	39705
2000	1737	3500	1803	32644	6225	42	5543	49757
2001	695	6961	1792	48938	1008	40	11122	69861
2002	11595	11595	1617	45430	1965	34	11218	71859
2003	9155	9155	1219	31366	5775	2	204	47721
2004	2889	7997	135	30891	5186	12	143	44364
2005	2575	6500	1487	35707	5271	19	1316	50300
2006	2655	8183	492	21308	6681		8157	44821
2007	2559	2985	208	18013	11725		6077	39008
2008	4304	4304	234	21111	39903		7814	73366
2009	4551	4551	92	24603	53385		8744	91375
2010	4041	4041	39	24652	57023		5800	91555

*some landings are based on expert jugement

EWG 11-16 notes that the landings listed are largely consistent with the quantities submitted to JRC trough the DCF 2011 Med and Black Sea data call issued on 3 August 2011.

7.1.2.3.2 Discards

No discards of sprat have been reported with the exception of Romanian reports giving figures of sprat discards. Such discards are very low.

7.1.2.4 Fishing effort

The following Tables 6.1.2.4..1 and 2 list the fishing effort data received from Member States through the official DCF data call in units of kW*days at sea and number of vessels.

Table 6.1.2.4.1 DCF nominal fishing effort (kw*days at sea) as submitted to JRC through the DCF 2011 Med and Black Sea data call by major gear type, 2008-2010.

AREA	COUNTRY	GEAR	2008	2009	2010
SA 29	BUL	-1	18573751	15363673	25526826
SA 29	BUL	GNS	15666852	36979225	55479310
SA 29	BUL	OTM	6128829	9918196	11860801
SA 29	ROM	FPN	75773	118771	105152
SA 29	ROM	GNS	3247650	3991915	3640469
SA 29	ROM	OTM	212604	10520	662

Table 6.1.2.4. 2 DCF fishing effort (number of vessels) as submitted to JRC through the DCF 2011 Med and Black Sea data call by major gear type, 2008-2010.

AREA	COUNTRY	GEAR	2008	2009	2010
SA 29	BUL	-1	270	245	299
SA 29	BUL	GNS	422	625	705
SA 29	BUL	OTM	24	32	26
SA 29	ROM	FPN	17	24	17
SA 29	ROM	GNS	116	114	127
SA 29	ROM	OTM	10	2	1

7.1.2.5 Commercial CPUE

Commercial CPUE $kg.h^{-1}$ has increased in Bulgarian and Ukrainian waters in the last years. In Romanian waters a significant drop of CPUE has been observed due to drastic reduction of the fishing fleet.

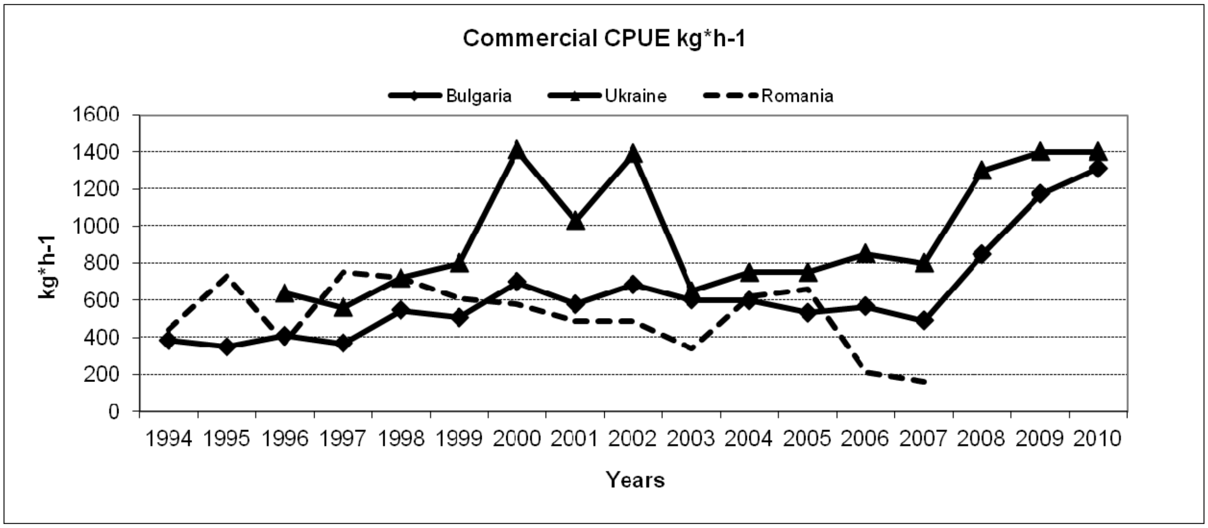


Figure 6.1.2.5.1. CPUE kg*h^{-1} derived from commercial fishery in Bulgaria, Ukraine and Romania

Table 6.1.2.5.1. Average CPUE kg.h^{-1} of sprat caught with pelagic trawls in Bulgaria in 2010.

European sprat					
SPR		LOA => 6<12	107.8	142.2	241.25
		LOA => 12<18	790	1356.25	1967.54
		LOA => 18<24	1418.84	1650.86	656.99
	OTM	LOA => 24<40	2442.48	2457.01	2035.4

The Ukraine sprat fishing has been carried out by 16 fishing vessels from March to October 2009. The maximum CPUE has been recorded in June-July (Tab. 6.1.2.5.2).

Tab. 6.1.2.5.2. CPUE kg/h *1000 of Ukrainian fishing vessels, 2010.

Years/months	I-III	IV-VI	VII-IX	X-XII	Average
1996	0.41	0.96	1.27	0.64	0.82
1997	0.36	0.84	1.11	0.56	0.72
1998	0.46	1.08	1.42	0.72	0.92
1999	0.50	1.20	1.58	0.80	1.02
2000	0.85	2.22	2.80	1.41	1.82
2001	0.65	1.55	2.00	1.03	1.31
2002	0.85	2.12	2.75	1.39	1.78
2003	0.45	1.10	1.45	0.65	0.91
2004	0.40	1.20	1.50	0.75	0.96
2005	0.48	1.10	1.55	0.75	0.97
2006	0.50	1.25	1.67	0.85	1.07
2007	0.45	1.20	1.55	0.80	1.00
2008	0.83	2.00	2.60	1.30	1.68
2009	0.85	2.10	2.75	1.40	1.78
2010	0.80	2.15	2.80	1.40	1.79

The Turkish sprat fishery has operated in spring and autumn/winter period with pelagic trawls for the last three (2008-2010) years for approximately 75 operational days per year (Fig. 6.1.2.5.2).Turkish sprat landings have increased significantly after 2006 and especially since 2008 (Fig. 6.1.2.5.3).

The production of sprat in Turkey reaches its maximum in March-April with about 60 % of total catch is obtained in these two months. The lowest catches are generally obtained in the beginning of fishing season 2 % in October, 4.4% in November, and 7.8% in December. In May, the catch is decreases to 5.2 %, because the season ends with 15 May and fisherman works only for 15 days in this month.

Figure 6.1.2.5.2. Turkey monthly landings rate distribution, 2009/10.

In 2010, 40 pairs of trawlers operated in the sprat fishery. As accepted more profitable then the bottom trawl fishery, a number of fishing vessels from western Black Sea, the Sea of Marmara, and even from the Aegean Sea move to the sprat fishery since 2008. In the first years of sprat fishing (the 1990s) only one or two pairs of trawlers were operating but in a five year time they reached up to 40-50 paired vessels (Figure 6.1.2.5.3). In general, a vessel in 18-30 m length obtains a catch of 10 or 15 tonnes/day on average. The amount of daily catch mostly depends on the fisherman experience and the quality of equipment.

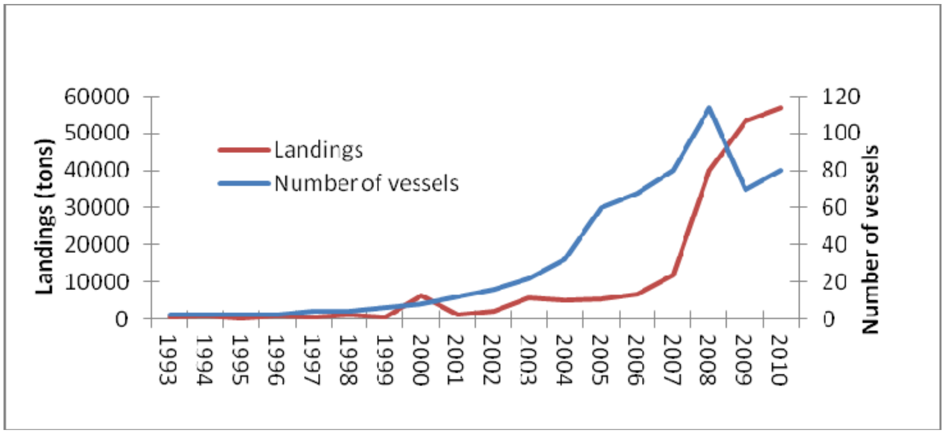


Figure. 6.1.2.5.3 Landings of sprat and number of active vessels for long term period in Turkey.

The catch is used in the production of fish meal and oil in the coastal processing plants. In the beginning, there was only two plants (DALYAN (Yakakent-Çayağzı) and SÜRSAN (Yakakent-Centre) for indusrial processing of sprat, today they are five. Three of these plants (SİDEMSAN (Gerze), SAMSUN BALIKÇILIK (Bafra) ve KARDEZ (Yakakent) became active in the fishing period of 2010/2011 and this is an indicator of growing importance of sprat. Formerly these plants were working mostly using anchovy, with short periods and under their capacities, now they are functional for a longer period due to the burgeonning sprat fishery.

Sprat fishing in Romanian waters is limited to the 60-70 m depth isobaths, as a consequence of the characteristics of the vessels and their limited autonomy. In 2010 the Romanian fleet has been droped to one fishing vessel with LOA = 24< 40 m.

7.1.3 Scientific Surveys

7.1.3.1 Method 1: International (Bulgarian and Romanian) Pelagic Trawl Survey (PTS), June 2010.

Joint Pelagic Trawl Survey was carried out in June - July 2010 in the Romanian and Bulgarian Black Sea waters. Each of the regional teams has produced biological analyses of the results obtained in their area. The research vessel and fishing gear applied in the Romanian area in previous years, were applied in both areas.

All analyses are based on the biomass and density estimates by geographical strata and by countries. All the teams calculated their standard statistical estimates using the same software.

Biological data collection using mid-water trawl supply scientists with valuable information of population parameters such as size, age, sex composition, condition factor. Estimates of abundance, spatial distribution and migration are important source of information concerning population dynamics.

In the conditions of the Black Sea sprat forms aggregations in the bottom layer bellow the thermocline. The main fishing gear in the sprat fishery is mid-water trawl (OTM) – operating near the bottom. In the Black Sea and especially in its northwestern part assessments based on trawl survey had been conducted for 30 years by Ukraine, and from around 20 years by Romania and Bulgaria.

Starting from 2011 hydro acoustic survey will be used to assess sprat biomass.

7.1.3.1.1 Geographical distribution patterns

The densest sprat aggregations were detected in the shallowest stratum 10-35 m with average value of catch per unit area of 16 404 kg.km^{-2} and with average CPUA of 7428.6 kg.km^{-2} from all investigated stratums. During the survey the highest biomass indices were established in the stratum localized close to the shore -10 – 35 m in Bulgarian marine area. The biomass index in this stratum was 30 796.5 t. In the rest of the stratums the biomass was 2-3 times lower than in the shallowest stratum. The size composition ranged from 4.0 to 12.0 cm, the age ranged from 0+ to 4-4+, as oldest age groups and young-of-the-year was presented with low percentage. In Romanian waters sprat biomass was very high (at almost 10 times) in shallowest waters (stratum 10-35 m) in comparison with the stratums more distant from the coast - 35-50 m and 50-75 m.

Distribution pattern of catches per unit area during the spring survey in 2010 is presented on Fig.6.1.3.1.1.1.

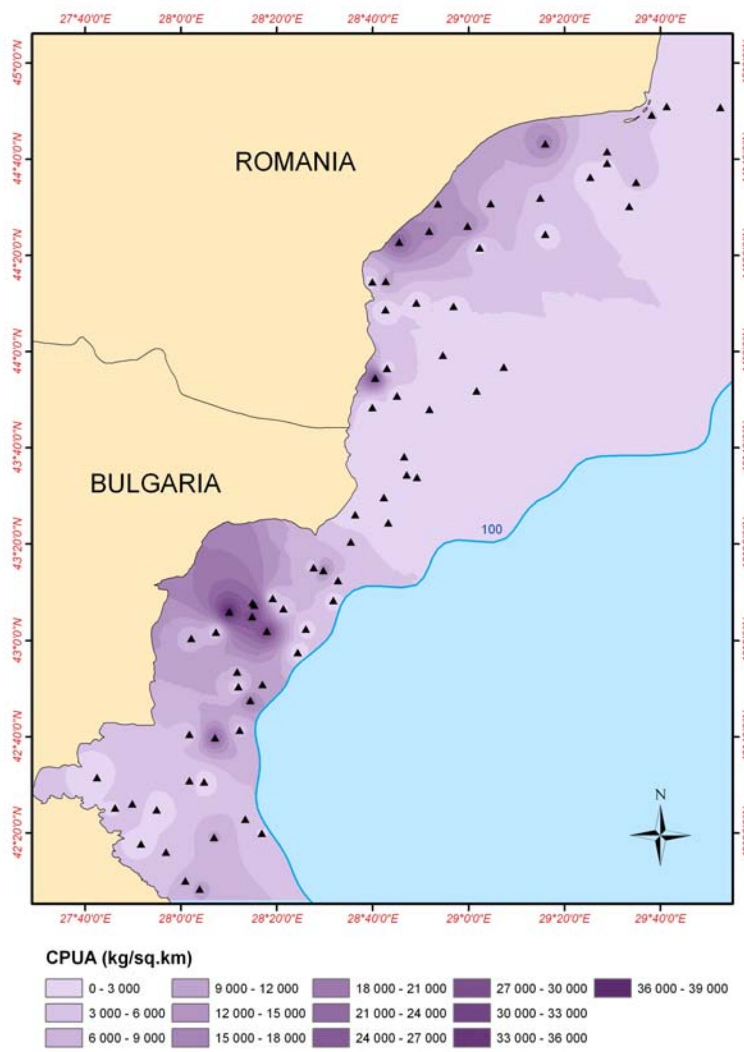
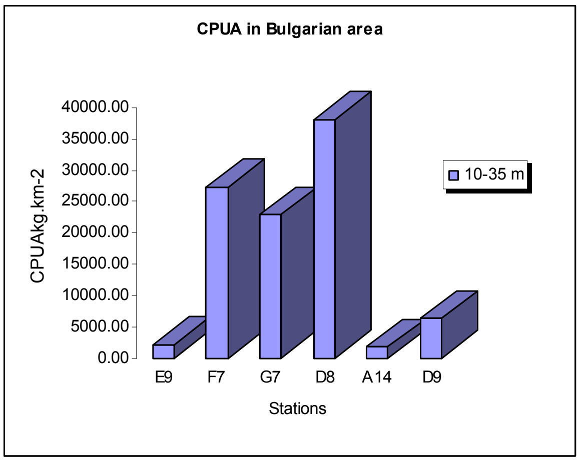
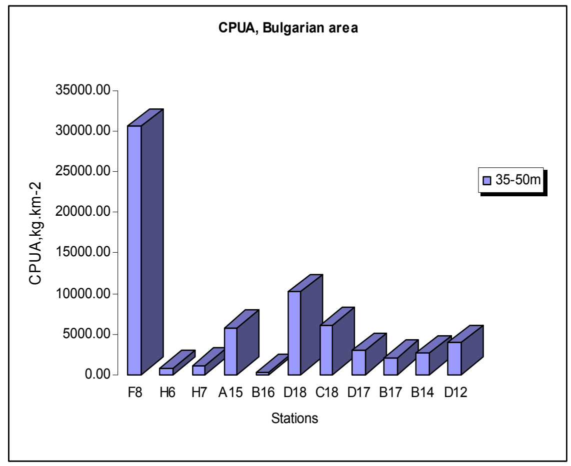


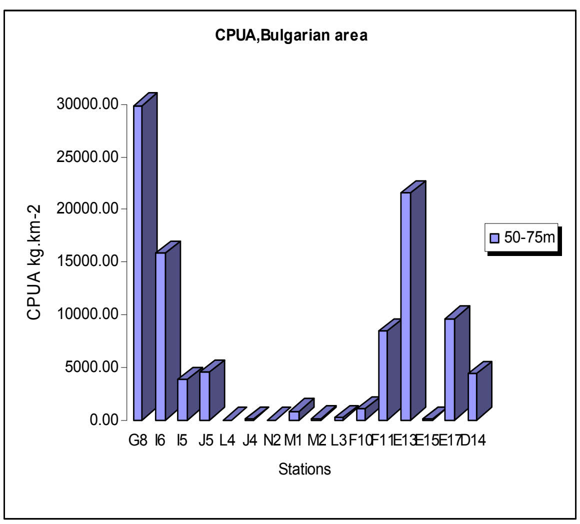
Figure. 6.1.3.1.1.1 Catch per unit area kg.km^{-2} in Bulgarian and Romanian areas from the spring PTS.

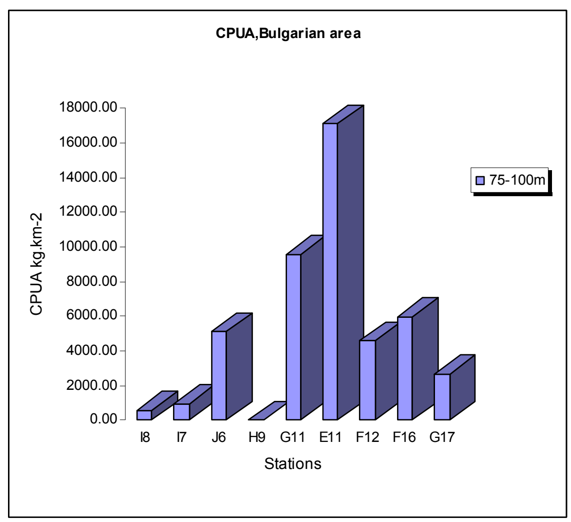
The calculated catches per unit area (CPUA) for the Bulgarian Black Sea area by strata are represented on Fig. 6.1.3.1.1.2.





(**a**) (**b**)





(**c**) (**d**)

Figure 6.1.3.1.1.2. CPUA kg.km^{-2} by strata in the Bulgarian marine area; (**a**) CPUA kg*km^{-2} at strata 10-35m; (**b**) CPUA kg*km^{-2} at strata 35-50m; (**c**) CPUA kg*km^{-2} at strata 50-75m;(**d**) CPUA kg*km^{-2} at strata 75-100m.

7.1.3.1.2 Trends in abundance at length or age

The CPUE indices of Romanian and Bulgarian pelagic trawl surveys are presented on Fig. 6.1.3.1.2.1. The trends show that Bulgarian biomass index increased in 2010 and the Romanian index stayed at the same level in 2008-2010.

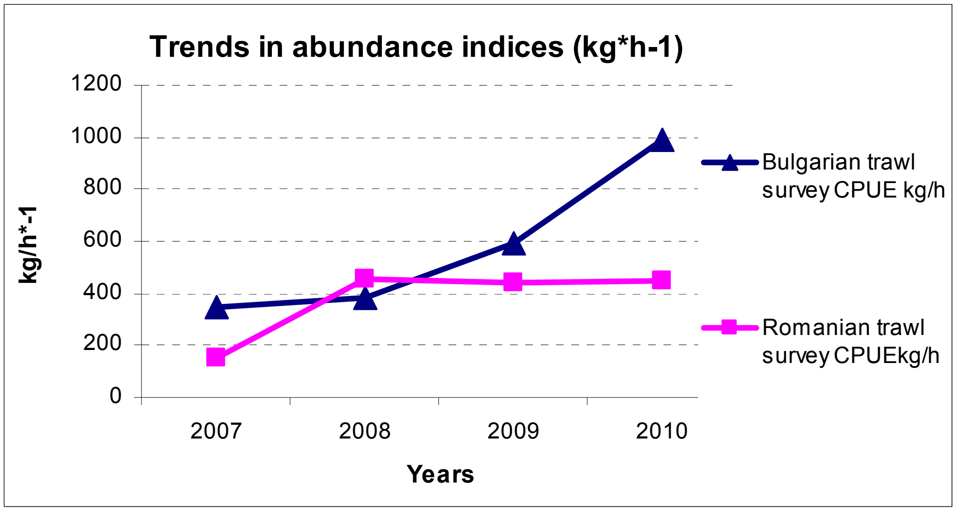
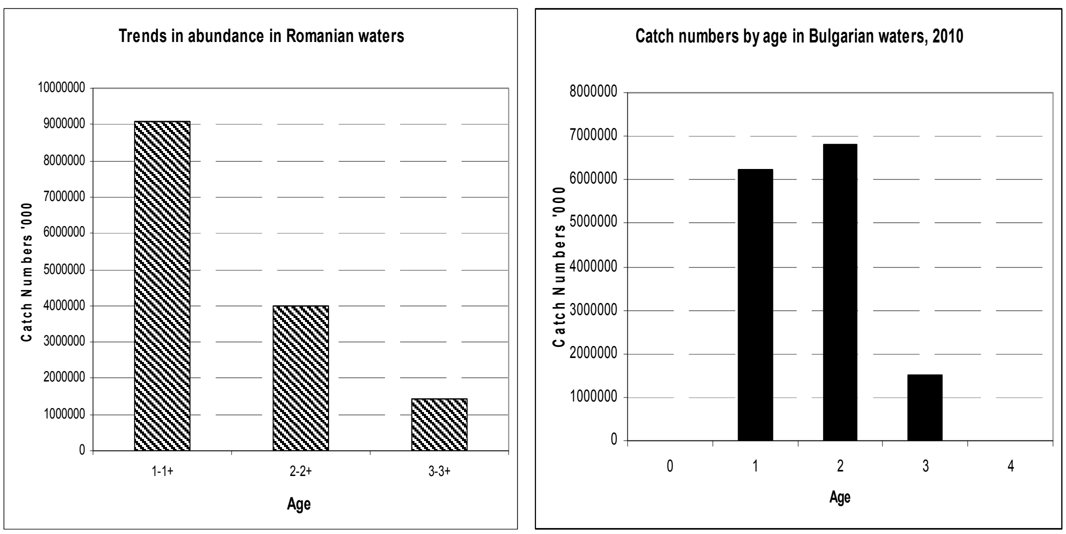


Figure 6.1.3.1.2.1. Trends in abundance (CPUE kg.h^{-1}) derived from Bulgarian and Romanian pelagic trawl surveys.

Catch numbers by age (Fig. 6.1.3.1.2.2) from surveys in Romania and Bulgaria show similar trends with prevailing age classes of 1-1+ and 2-2+.



(**a**) (**b**)

Figure 6.1.3.1.2.2. Trends in abundance by age from surveys in Romania (**a**) and Bulgaria **(b**).

Commercial catch in Bulgaria was composed from 1-1+ and 2-2+ old specimen, mainly. Similar trends were observed in scientific surveys. Samples collected from Turkish pelagic trawls operating in shallow waters (40-60 m) also confirm the tendency that larger/older fish (Age 3 and 4) is distributed mostly in deeper waters (Fig. 6.1.3.1.2.3).

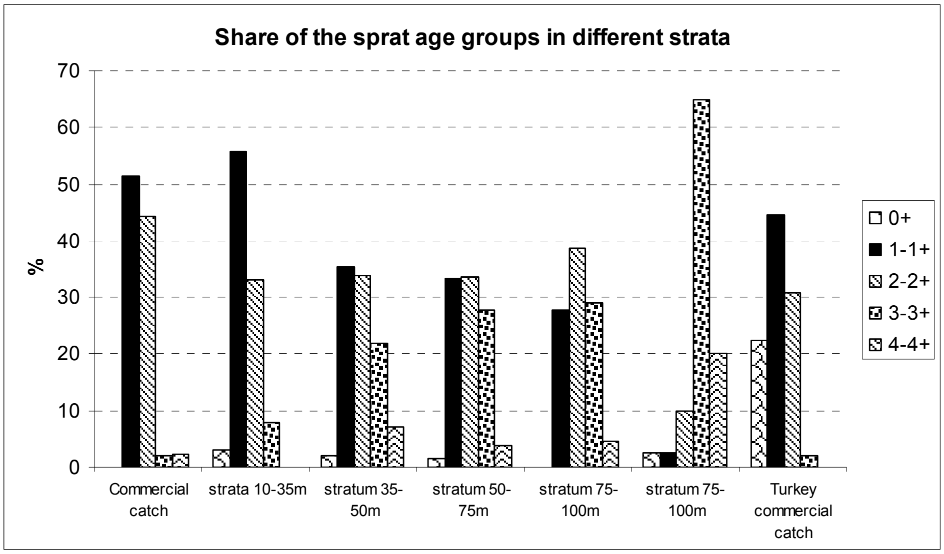


Figure 6.1.3.1.2.3. Age composition of commercial and survey catches of sprat showing lower selectivity of larger/older fish by the Bulgarian commercial fleet and in shallower waters.

7.1.3.1.3 Trends in growth

Length has bimodal distribution in terms of (85-90mm) and (90-95mm). Sub dominated are the ranges 80-85 and 95-100mm.

7.1.3.1.1 Trends in maturity

No analyses were conducted in 2010.

7.1.3.2 Method 2: Pilot international hydroacoustic survey in December, 2010

A pilot acoustic survey was conducted in front of the Bulgarian and Romanian Black Sea coasts, over the continental shelf between 42º50´ N and 43°50´ N and 28°00´ E and 29°30´ E in December 2010. Acoustic data were collected by using of EK 60 system (SIMRAD), operating at 38, 120 and 200 kHz simultaneously with hull-mounted split-beam transducers on the R/V “Akademik”, Institute of Oceanology, Varna - Bulgarian Academy of Sciences. The main frequency for the assessment of fish biomass was 38 kHz. The 120 kHz and 200 kHz frequencies were used for discriminating fish, plankton, noise etc. GPS data were collected for pairing acoustic density readings with geographic location. A mid-water trawl, equipped with monitoring system based on SIMRAD ITI sensor was used for direct fishing and estimation of species composition and size frequency distribution. The ITI measures the trawl depth, vertical opening of the trawl mouth and temperature at the trawl depth.

The target fish species were sprat (*S. sprattus*) and whiting (*M. merlangus*). Furthermore, for zooplankton sampling, vertical Juday net (0.1 m^2, 200 µm mesh size) was used. Environmental measurements in each station were performed by CTD Seabird 911 sensor system for variables – temperature, salinity and dissolved oxygen, analyzed by Winkler method.

Systematic parallel design was employed during the pilot hydroacoustic survey. For acoustic data acquisition, detailed echogram analysis and related calculations, the post-processing system LSSS was used. Data acquired by the 38 kHz transducer were used for extracting the sA values (nautical acoustic scattering coefficient (NASC), $m^2.nmi^{-2}$). The echointegration interval was 1 nm (1852 m).

For each species different target strength (TS) relationship was used. As no TS-length (L) relationship has been established for the two species, for this study the following target strength-length (TS) relationships were adopted:

Clupeoids: TS = 20 log L (cm) – 71.2

Gadoids: TS = 20 log L (cm) – 67.4

For biomass estimates, the surveyed area was divided into 4 polygons. For each polygon, the species composition in the identification hauls enabled sprat and whiting sA values to be estimated according to their proportion (in weight) in the catch. The biomass for each species was computed as the integral of surface density on the investigation area.

7.1.3.2.1 Geographical distribution

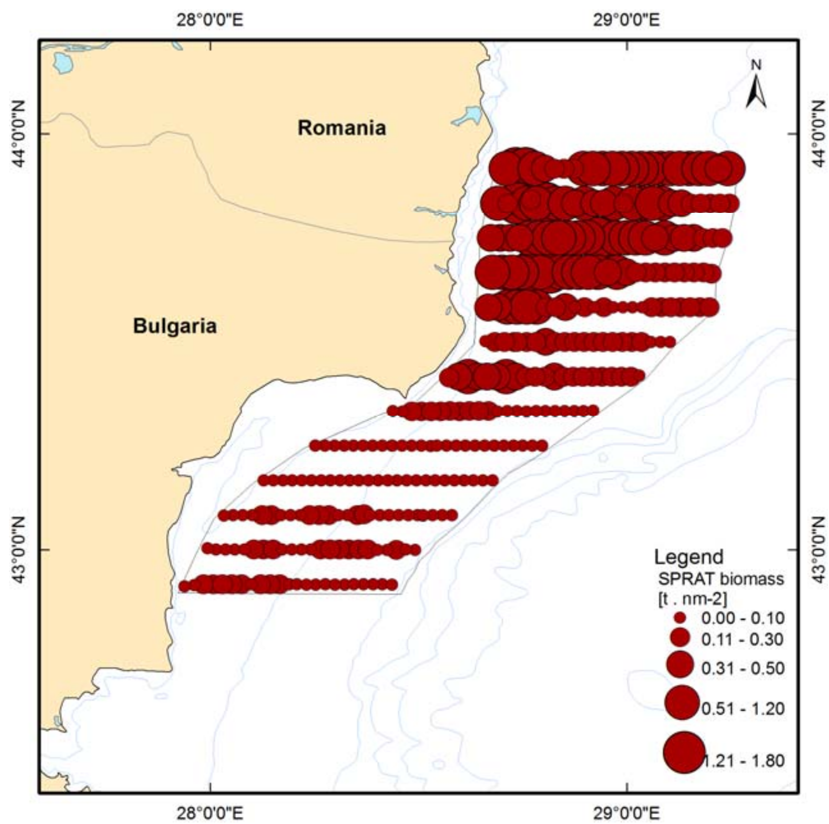


Fig. 6.1.3.2.1.1. Distribution map of sprat biomass values ($t.nm^{-2}$), obtained during the acoustic survey of R/V "Akademik" in December 2010.

7.1.3.2.2 Abundance and biomass

Estimated abundance and biomass of sprat and whiting in the surveyed area are presented on Tables 6.1.3.2.2.1.1-2.

Table 6.1.3.2.2.1. Estimated number of sprat and whiting (millions) by age group and polygon, December 2010.

Polygon	Sprat ($*10^3$)	Whiting ($*10^3$)	Age groups (nbs, M)								
			S. sprattus				*M. merlangus*				
			1	2	3	4	1	2	3	4	5
1	16.75	24.628	7.92	7.67	1.16		8.132	9.99	3.02	3.25	0.23
2	1.7	2209.09	0.64	0.69	0.36	0.01	718.61	928.38	285.49	199.55	77.06
3	19.48		11.2	7.27	0.97	0.04					
4	63.57		37.22	25.75	0.61						
Total	101.5	2233.72	56.98	41.38	3.1	0.05	726.74	938.37	288.51	202.8	77.29

Table 6.1.3.2.2.2. Estimated biomass of sprat and whiting (tones) by age group and polygon, December 2010.

Polygon	Sprat (t)	Whiting (t)	Age groups (nbs, M)								
			S.sprattus				*M.merlangus*				
			1	2	3	4	1	2	3	4	5
1	67.58	0.48	28.85	32.7	6.03		0.08	0.15	0.09	0.15	0.02
2	7.41	33.86	2.4	2.94	1.97	0.1	5.71	10.22	5.75	7.55	4.63
3	81.93		44.33	31.54	5.75	0.3					
4	287.54		164.19	119.56	3.8						
Total	444.46	34.34	239.77	186.74	17.55	0.4	5.79	10.37	5.84	7.7	4.65

7.1.4 Assessment of historic parameters

7.1.4.1 Method 1: ICA

7.1.4.1.1 Justification

We used Integrated Catch-at-age Analysis (ICA; Patterson and Melvin, 1996). ICA is a statistical catch-at-age method based on the Fournier and Deriso models (Deriso et al., 1985). It applies a statistical optimization procedure to calculate population numbers and fishing mortality coefficients-at-age from data of catch numbers-at-age and natural mortality. The dynamics of a cohort (generation) in the stock are expressed by two non-linear equations referred to as a survival equation (exponential decay) and a catch equation:

$N_{a+1,y+1} = N_{a,y} * exp(-F_{a,y} - M)$,

$C_{a,y} = N_{a,y} * [1 - exp(-F_{a,y} - M)] * F_{a,y} / (F_{a,y} + M)$,

where C, N, M, and F are catch, abundance, natural mortality, and fishing mortality, respectively, and a and y are subscript indices for age and year.

The algorithm initially estimates population numbers and fishing mortality fitting a separable model, when F is assumed to conform to a constant selection pattern (fishing mortality-at-age), but fishing mortality by year is allowed to vary. The F matrix is then modelled as a multiplication of the year-specific F and the specified selection pattern. This procedure substantially diminishes the number of parameters in the model.

In its second stage, the ICA algorithm minimizes the weighted Sum of Square Residuals (SSR) of observed and modelled catch and relative abundance indices (CPUE), assuming Gaussian distribution of the log residuals:

$min\ [\sum_{a,y} pc_{a,y}\ (log\ C_{a,y} - log\ \hat{C}_{a,y})^2 + \sum_{a,y,f} pi_{a,f}\ (log\ I_{a,y,f} - log\ \hat{I}_{a,y,f})^2,$

where C, Ĉ, I, and Î are observed and estimated catch and age-structured index, respectively, and a, y, and f are subscript indices for age, year, and fleet, respectively. Weights associated with catches and different indices (pc, pi) are ideally set equal to the inverse variances of catch and index data, and can be calculated based on the residuals between modelled and observed values. However, weights are usually set by the user on the basis of some information about the reliability of different indices and current experience with modelling the stock. Indices are defined as related to population numbers by the equations:

$\hat{I}_{a,y} = N_{a,y} * exp(-F_{a,y} - M)$

$\hat{I}_{a,y} = q_a * N_{a,y} * exp(-F_{a,y} - M)$

$\hat{I}_{a,y} = q_a * (N_{a,y} * exp(-F_{a,y} - M))^k{}_a\ .$

The two unknown parameters (qa, an age-specific catchability, and k, a constant) are estimated according to the assumed relationship between the population and the abundance index, which has to be specified as being one of the above – identity, linear, or power, respectively.

ICA combines the power and accuracy of a statistical model with the flexibility of setting different options of the parameters (e.g. a separable model accounting for age effects) and for this raison is suitable for a short living species (age 5 at maximum) such as the Black Sea sprat. ICA has previously been applied to Black Sea sprat by Daskalov (1998), Pilling et al. 2009, and Daskalov et al. 2010.

7.1.4.1.2 Input parameters

Catch and weight at age, natural mortality, and 4 age structured indices are used to run ICA (Table 6.1.4.1.2.1). New data from the Turkish sprat fisheries were added to the input catch-at-age matrix that improved the data quality and consistency of the analyses. The e timing of the meeting of the STECF SG Black Sea was convenient in order to have officially published (at the end September) fisheries information from Turkey,.

Adult stock indices are derived from commercial CPUE of Bulgarian and Ukrainian trawling fleets. Previously used index of juvenile fish (age 0.5 in July) from Romanian juvenile survey, was dropped because the surevey seased in 2008. Two new tunning indices: from the Bulgarian and Romanian Pelagic Trawl Surveys (PTS) were introduced into the assessment (Table 6.1.4.1.2.1).

Table 4.1.4.1.2.1. Sprat input parameters.

```
Output Generated by ICA Version 1.4
 -----------------------------------

       SPRAT 2010
       ----------

       Catch in Number
       ---------------
------+---------------------------------------------------------------------------------------------------------------------------
AGE   |    1991    1992    1993    1994    1995    1996    1997    1998    1999    2000    2001    2002    2003    2004    2005
------+---------------------------------------------------------------------------------------------------------------------------
  0   |    492.     51.    255.    115.     21.    108.    278.    236.   1009.    406.    809.    415.   1202.    445.    528.
  1   |   8047.   2673.   2673.   2072.   1712.   2496.   2741.   2278.   3838.   4877.  10352.   6829.   5654.   6878.   6024.
  2   |   1363.   2114.   1453.   2182.   2792.   2773.   2600.   2831.   3086.   3340.   6646.   7655.   5454.   3580.   4652.
```

AGE															
3	106.	528.	218.	442.	418.	579.	830.	1741.	1302.	1313.	1269.	3090.	3024.	2666.	1602.
4	55.	96.	14.	13.	13.	17.	43.	82.	121.	110.	109.	182.	674.	278.	372.
5	0.	7.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

x 10 ^ 6

Catch in Number

AGE	2006	2007	2008	2009	2010
0	1158.	3180.	1299.	1558.	2934.
1	5976.	5351.	7774.	12266.	7940.
2	2705.	1876.	3248.	7833.	7120.
3	785.	802.	1327.	3278.	4378.
4	92.	113.	168.	369.	316.
5	0.	0.	0.	0.	1.

x 10 ^ 6

Predicted Catch in Number

AGE	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	627.	798.	732.	1080.	1044.	1127.	1015.	1841.	2934.
1	6940.	5578.	4745.	6530.	5074.	5156.	7300.	12297.	13870.
2	6191.	6715.	3534.	4379.	3171.	2787.	3834.	9540.	9124.
3	3122.	3011.	2049.	1542.	972.	883.	1106.	2526.	3117.
4	170.	536.	301.	312.	105.	88.	121.	269.	273.

x 10 ^ 6

Weights at age in the catches (Kg)

AGE	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	.001500	.001700	.001700	.002300	.002500	.002500	.002300	.002400	.002800	.002300	.001700	.001800	.001700	.001900	.002100
1	.002100	.002100	.002500	.003400	.003800	.003800	.003300	.004000	.003200	.003500	.002500	.002700	.002800	.002900	.003500
2	.004400	.004500	.003600	.004000	.004600	.005200	.004900	.005100	.005000	.004500	.004000	.004100	.004000	.004400	.004700
3	.007100	.006800	.006000	.004700	.005400	.006000	.006300	.007600	.006500	.006000	.006300	.005800	.006100	.006000	.006200
4	.009400	.008600	.007700	.007700	.006900	.007400	.007200	.009400	.007300	.007800	.006900	.007700	.006800	.007300	.007700
5	.010800	.010800	.010800	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000

Weights at age in the catches (Kg)

AGE	2006	2007	2008	2009	2010
0	.002000	.001700	.002300	.002400	.002100
1	.003300	.003300	.003400	.003100	.002900
2	.004300	.004900	.004300	.004000	.004400
3	.006000	.007200	.005200	.004900	.006500
4	.007300	.008700	.007000	.006000	.008000
5	.010000	.010000	.010000	.010000	.010000

Weights at age in the stock (Kg)

AGE	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	.001500	.001700	.001700	.001000	.001000	.001000	.001000	.001000	.001000	.001000	.001000	.001000	.001000	.001000	.001000
1	.002100	.002100	.002500	.003500	.003300	.002800	.002700	.003400	.002500	.003200	.003500	.003600	.003500	.003400	.003600
2	.004400	.004500	.003600	.004100	.004300	.004300	.004700	.004600	.004700	.004400	.004400	.004500	.004400	.004400	.004600
3	.007100	.006800	.006000	.004800	.004800	.004700	.005700	.006400	.005900	.005600	.005200	.006100	.005900	.006000	.006100
4	.009400	.008600	.007700	.006200	.005500	.005300	.006900	.008200	.007300	.007200	.006700	.007400	.007400	.007200	.007400
5	.010800	.010800	.010800	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000	.010000

Weights at age in the stock (Kg)

AGE	2006	2007	2008	2009	2010
0	.001000	.001000	.001000	.001000	.001000
1	.003600	.003600	.003100	.003100	.002500
2	.004600	.004700	.004200	.004100	.003500
3	.005700	.006300	.005600	.004700	.004500
4	.007400	.007600	.007000	.005400	.007100
5	.010000	.010000	.010000	.010000	.016000

Natural Mortality (per year)

AGE	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000	0.64000

1	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000
2	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000
3	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000
4	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000
5	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000	0.95000

Natural Mortality (per year)

AGE	2006	2007	2008	2009	2010
0	0.64000	0.64000	0.64000	0.64000	0.64000
1	0.95000	0.95000	0.95000	0.95000	0.95000
2	0.95000	0.95000	0.95000	0.95000	0.95000
3	0.95000	0.95000	0.95000	0.95000	0.95000
4	0.95000	0.95000	0.95000	0.95000	0.95000
5	0.95000	0.95000	0.95000	0.95000	0.95000

Proportion of fish spawning

AGE	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Proportion of fish spawning

AGE	2006	2007	2008	2009	2010
0	0.0000	0.0000	0.0000	0.0000	0.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000

AGE-STRUCTURED INDICES

Bul

AGE	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	9.78	19.59	41.06	53.32	52.36	101.06	96.51	87.64	69.14	73.95	80.74	58.86	73.12	65.32	77.50
2	57.49	48.77	38.16	28.37	58.52	30.60	68.95	60.47	66.09	64.79	54.65	38.78	38.98	37.62	70.25
3	16.27	7.36	9.45	6.21	5.28	4.54	6.28	3.43	21.45	18.67	19.65	13.08	7.58	11.60	50.73
4	0.25	0.23	0.59	0.61	0.54	0.30	0.61	0.20	1.16	3.34	4.85	1.31	2.35	1.98	5.04

x 10 ^ 3

Bul

AGE	2009	2010
1	125.36	107.72
2	109.76	117.60
3	37.33	90.32
4	5.98	10.33

x 10 ^ 3

Ukr

AGE	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	124.38	80.94	111.12	58.09	59.67	97.40	222.49	193.27	158.30	76.22	125.47	113.57	180.31	127.15	284.84
2	74.90	103.68	118.27	50.40	68.14	85.43	146.35	118.28	179.30	76.02	46.40	88.14	69.18	24.19	55.49
3	8.05	9.43	9.43	10.52	46.52	37.49	66.40	22.53	76.56	47.52	54.76	29.98	24.67	16.90	37.53
4	0.51	0.14	0.66	0.72	2.36	0.56	6.10	2.15	4.65	10.87	5.06	8.06	2.52	0.10	3.07

x 10 ^ 3

Ukr

AGE	2009	2010
1	335.38	352.09
2	143.30	67.33

AGE		
3	37.47	4.84
4	0.66	0.24

x 10 ^ 3

Bul survey

AGE	2007	2008	2009	2010
1	19352.	44034.	55081.	88238.
2	30667.	40393.	55722.	84987.
3	25733.	12928.	40543.	53350.
4	999.	1081.	9585.	7495.

Rom survey

AGE	2007	2008	2009	2010
1	20.57	72.15	53.94	135.33
2	26.50	40.97	72.32	26.07

x 10 ^ 3

7.1.4.1.3 Results

ICA was run assuming a constant selection pattern in 2002-2010 (Fig. 6.1.4.1.3.1, Table 6.1.4.1.3.1) with reference F at age 2 and Selection at the last ‘real’ age (S4) equal 1.

The results of the ICA show a reasonable agreement with tuning data (Fig. 6.1.4.1.3.3. Fig. 6.1.4.1.3.4. Fig. 6.1.4.1.5.). The overall fit and partial SSR converged to unique minima (Fig. 6.1.4.1.3.6).

Shrinking of the terminal Fs in the last year was applied using the last 7 years of the originally estimated F matrix (Table 6.1.4.1.3.1.).

The analysis of the main population parameters (abundance, catch, fishing mortality, Fig. 6.1.4.1.3.6. Table 6.1.4.1.3.1.) shows that the sprat stock has recovered from the depression in the 1990s due to good recruitment in 1999-2001 and the biomass and catches have gradually increased over the 1990s and during the 2000s reached levels comparable to the previous period of high abundance 1975-1989 (Fig. 6.1.4.1.3.8). The stock estimates reveal the cyclic nature the sprat population dynamics. The years with strong recruitment were followed by years of low to medium recruitment which leads to corresponding changes in the the Spawning Stock Biomass (SSB). High fishing mortalities (F_{1-3}) were observed during the stock collapse in the early 1990s, in 2005, and 2009-2010 when catches reached the third highest level due to the intensive development of the Turkish sprat fishery. Over the last 4 years the levels of recruitment, biomass and catches are comparable with the highest figures reported.

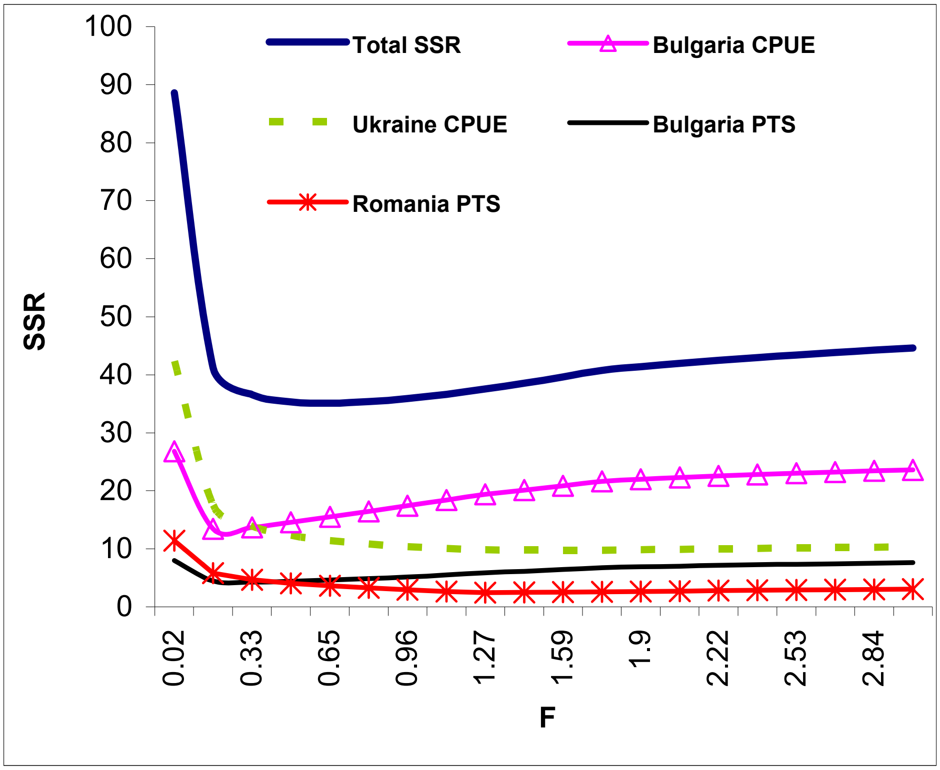


Fig. 6.1.4.1.3.1. Trajectories of the total Sum of Squared Residuals (SSR) and the partial SSRs of the two tuning fleets as functions of the reference F.

Fig. 6.1.4.1.3.2. Selection pattern estimated by the separable model

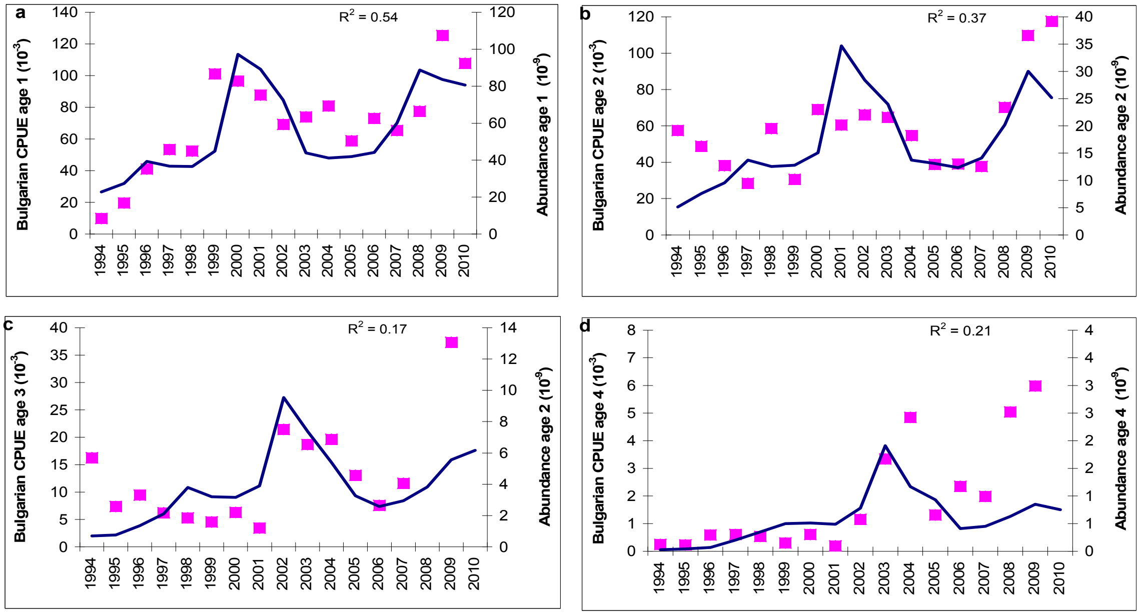


Fig. 6.1.4.1.3.3. Adjustment of ICA: time-series of estimated abundance-at-age and age-structured Bulgarian CPUE (best fit is given by linear relationships and r^2 are displayed): (a) Age 1, (b) Age 2, (c) Age 3, (d) Age 4.

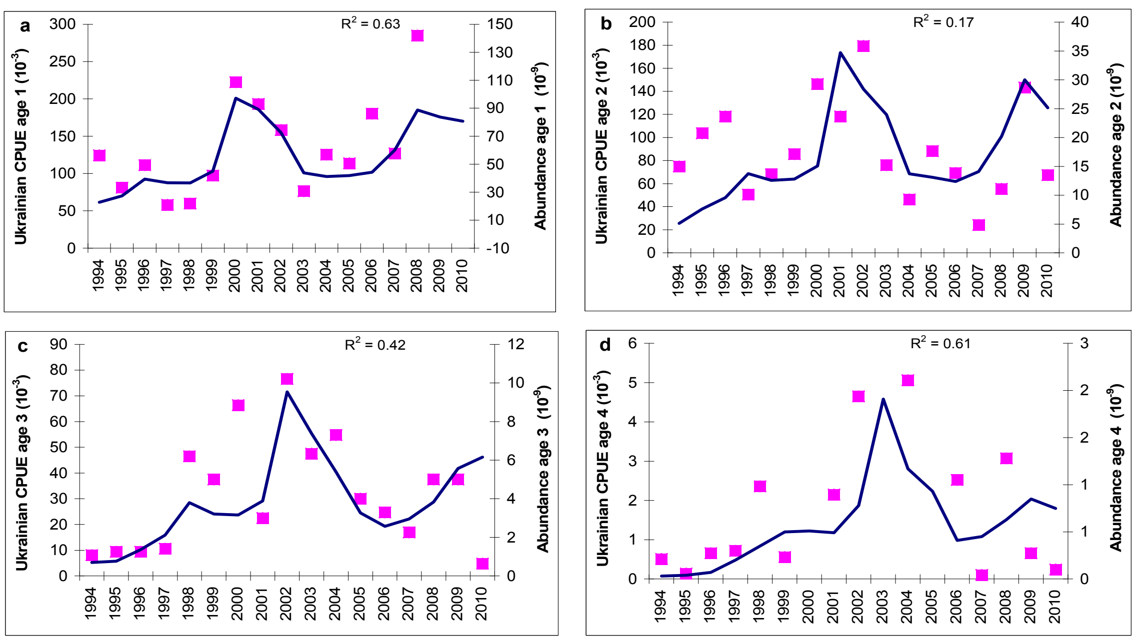


Figure 6.1.4.1.3.4. Adjustment of ICA: time-series of estimated abundance-at-age and age-structured Ukrainian CPUE (best fit is given by linear relationships and r^2 are displayed): (a) Age 1, (b) Age 2, (c) Age 3, (d) Age 4.

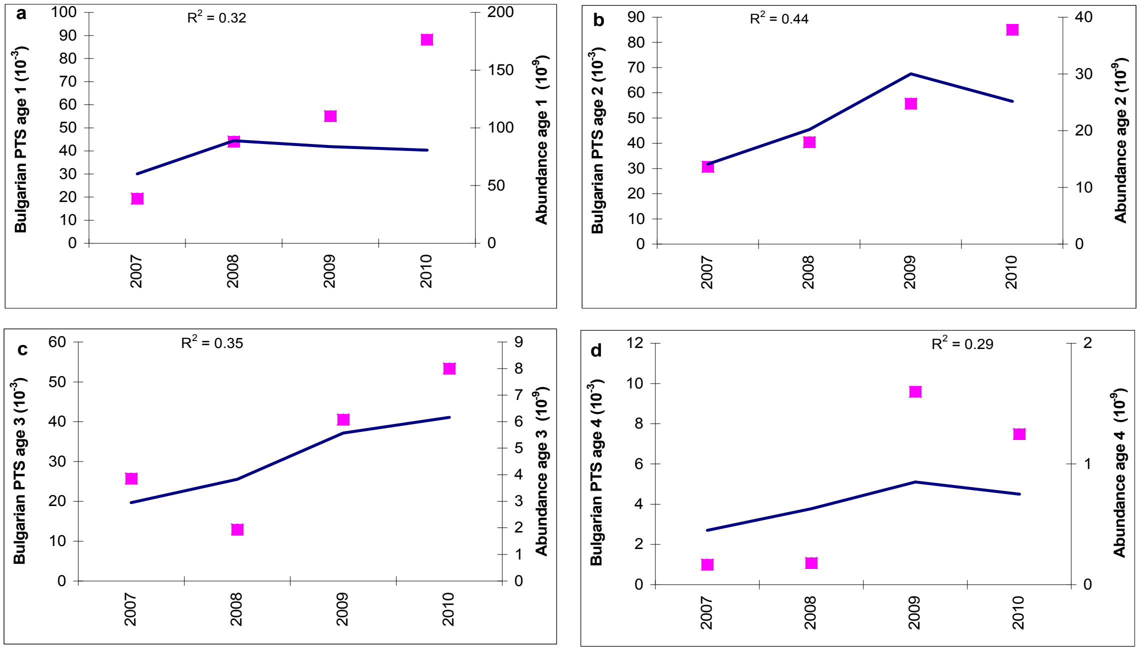


Figure 6.1.4.1.3.5. Adjustment of ICA: time-series of estimated abundance-at-age and age-structured Bulgarian PTS (best fit is given by linear relationships and r^2 are displayed): (a) Age 1, (b) Age 2, (c) Age 3, (d) Age 4.

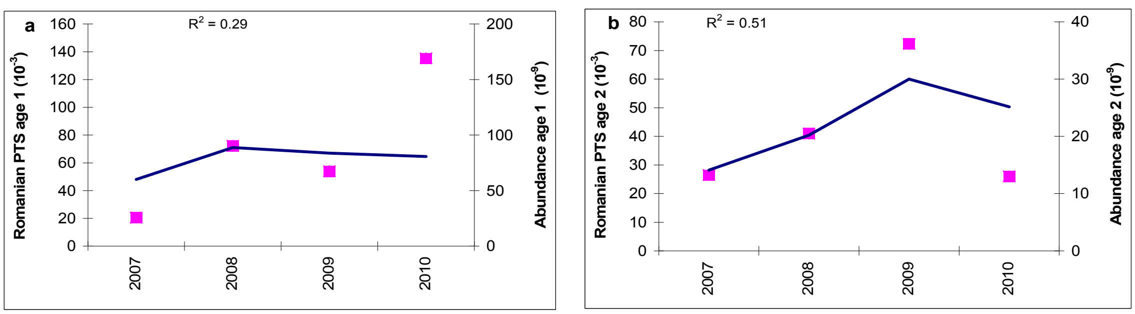


Figure 6.1.4.1.3.6. Adjustment of ICA: time-series of estimated abundance-at-age and age-structured Romanian PTS (best fit is given by linear relationships and r^2 are displayed): (a) Age 1, (b) Age 2.

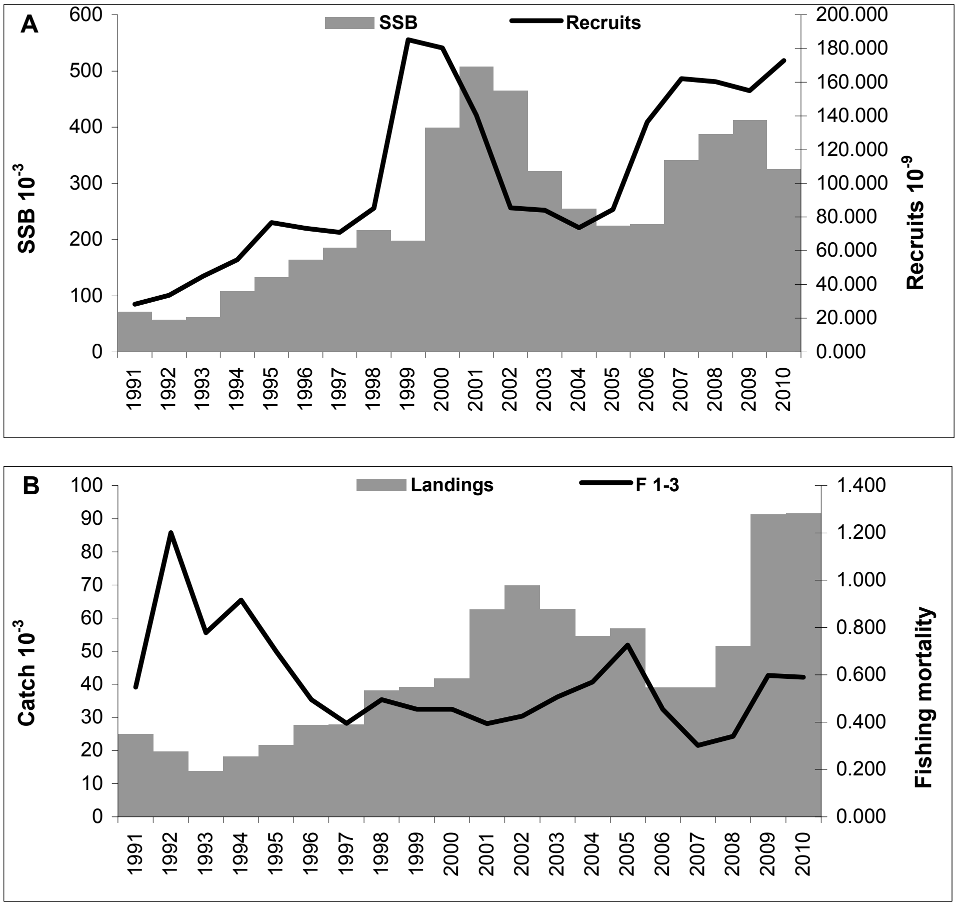


Fig. 6.1.4.1.3.7. Time-series of sprat population estimates: A. recruitment (line) and SSB (grey); B. landings (grey) and average fishing mortality (ages 2–4, line).

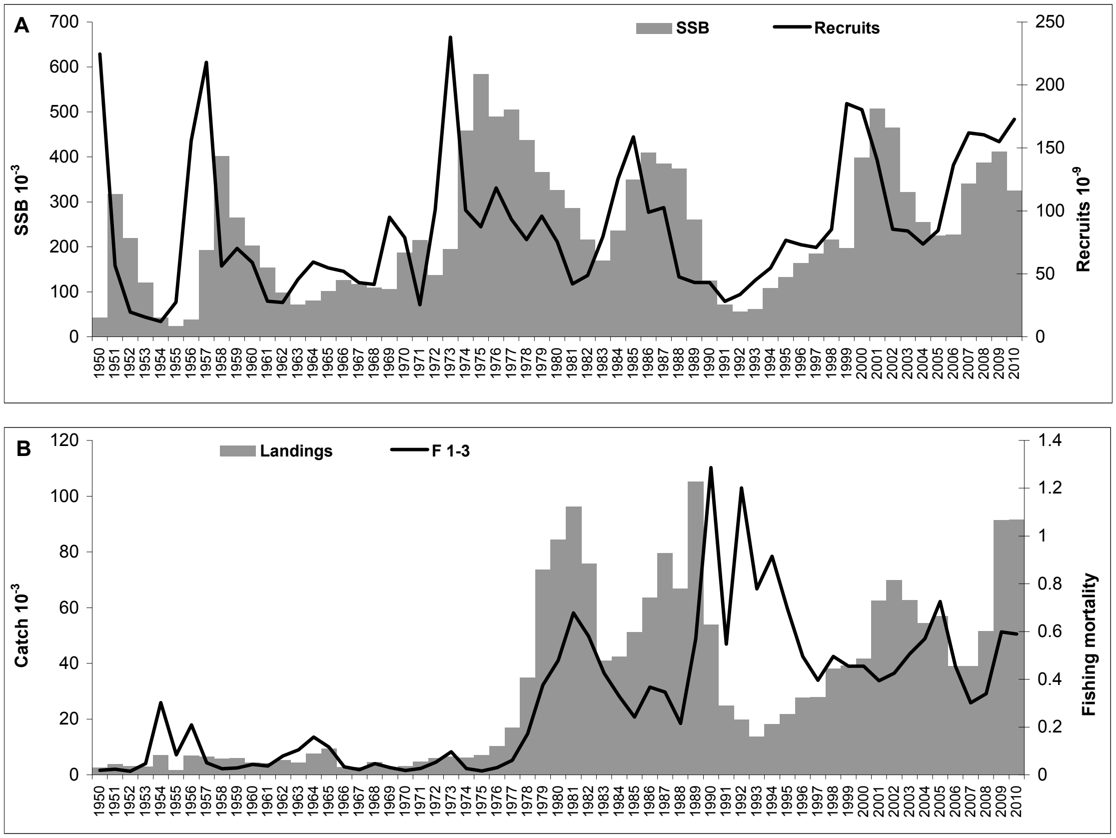


Fig. 6.1.4.1.3.8. Time-series of sprat population estimates – present results combined with historical estimates from Daskalov 1998a: A. recruitment (line) and SSB (grey); B. landings (grey) and average fishing mortality (ages 2–4, line).

Table 4.1.6.3.1. Sprat in the Black Sea 1990-2009: ICA results and diagnostics.

Fishing Mortality (per year)

AGE	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.0244	0.0021	0.0079	0.0030	0.0004	0.0021	0.0054	0.0037	0.0074	0.0032	0.0079	0.0101	0.0138	0.0124	0.0173
1	0.7637	0.3343	0.2674	0.1499	0.1012	0.1027	0.1218	0.1007	0.1406	0.0804	0.1949	0.1583	0.2151	0.1938	0.2700
2	0.6740	1.3705	0.7762	0.9538	0.7713	0.5628	0.3369	0.4129	0.4483	0.4049	0.3411	0.3971	0.5395	0.4862	0.6773
3	0.2724	2.0927	1.5015	1.9232	1.4425	0.9551	0.8492	1.0699	0.8847	0.9196	0.6561	0.6580	0.8939	0.8055	1.1223
4	0.9180	1.1573	0.7843	0.8302	0.6318	0.4656	0.3850	0.4371	0.4450	0.3872	0.4087	0.3971	0.5395	0.4862	0.6773
5	0.9180	1.1573	0.7843	0.8302	0.6318	0.4656	0.3850	0.4371	0.4450	0.3872	0.4087	0.3971	0.5395	0.4862	0.6773

Fishing Mortality (per year)

AGE	2006	2007	2008	2009	2010
0	0.0123	0.0090	0.0086	0.0162	0.0193
1	0.1925	0.1410	0.1347	0.2525	0.3016
2	0.4829	0.3536	0.3379	0.6334	0.7565
3	0.8002	0.5859	0.5599	1.0495	1.2534
4	0.4829	0.3536	0.3379	0.6334	0.7565
5	0.4829	0.3536	0.3379	0.6334	0.7565

Population Abundance (1 January)

AGE	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	27.59	32.85	43.57	52.02	74.59	69.70	69.69	85.33	185.74	169.68	138.63	84.13	79.02	80.37	85.31
1	22.02	14.20	17.29	22.79	27.35	39.31	36.67	36.55	44.83	97.22	89.18	72.52	43.91	41.10	41.86
2	4.09	3.97	3.93	5.12	7.59	9.56	13.72	12.56	12.78	15.06	34.69	28.38	23.94	13.70	13.09
3	0.68	0.81	0.39	0.70	0.76	1.36	2.11	3.79	3.21	3.16	3.89	9.54	7.38	5.40	3.26
4	0.13	0.20	0.04	0.03	0.04	0.07	0.20	0.35	0.50	0.51	0.49	0.78	1.91	1.17	0.93
5	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

x 10 ^ 9

Population Abundance (1 January)

AGE	2006	2007	2008	2009	2010	2011
0	115.34	169.90	160.11	155.38	207.64	113.97
1	44.21	60.08	88.78	83.70	80.62	107.39
2	12.36	14.10	20.18	30.01	25.15	23.06
3	2.57	2.95	3.83	5.57	6.16	4.56
4	0.41	0.45	0.63	0.85	0.75	0.68
5	0.00	0.00	0.00	0.00	0.00	0.14

x 10 ^ 9

Weighting factors for the catches in number

AGE	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Predicted Age-Structured Index Values

Bul Predicted

AGE	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	27.46	33.77	48.51	44.82	45.14	54.27	121.29	105.07	87.02	51.22	48.45	47.50	52.15	72.72	107.80
2	14.53	23.61	33.01	53.05	46.74	46.74	56.29	133.86	106.48	83.65	49.15	42.70	44.42	54.08	77.98
3	1.75	2.43	5.51	9.01	14.52	13.51	13.04	18.31	44.92	30.88	23.61	12.16	11.28	14.39	18.94
4	0.09	0.11	0.22	0.65	1.09	1.57	1.65	1.55	2.49	5.68	3.57	2.59	1.26	1.46	2.09

x 10 ^ 3

Bul Predicted

AGE	2009	2010
1	95.82	90.05
2	100.04	78.83
3	21.55	21.54
4	2.40	2.01

x 10 ^ 3

Ukr Predicted

AGE	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	61.69	75.86	108.96	100.68	101.40	121.91	272.47	236.03	195.48	115.06	108.83	106.70	117.16	163.35	242.16
2	21.62	35.11	49.10	78.90	69.51	69.51	83.72	199.08	158.36	124.40	73.09	63.51	66.05	80.43	115.98
3	3.34	4.63	10.51	17.20	27.71	25.78	24.89	34.95	85.73	58.94	45.06	23.21	21.53	27.47	36.15
4	0.10	0.13	0.25	0.74	1.25	1.80	1.89	1.77	2.86	6.52	4.09	2.97	1.44	1.67	2.39

x 10 ^ 3

Ukr Predicted

AGE	2009	2010
1	215.24	202.29
2	148.78	117.24
3	41.13	41.11
4	2.75	2.31

x 10 ^ 3

Bul survey Predicted

AGE	2007	2008	2009	2010
1	36172.	53625.	47663.	44796.
2	35047.	50537.	64832.	51086.
3	22227.	29250.	33279.	33258.
4	2211.	3164.	3639.	3048.

Rom survey Predicted

AGE	2007	2008	2009	2010
1	46004.	68200.	60618.	56971.
2	26936.	38841.	49828.	39263.

Fitted Selection Pattern

AGE	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	0.0362	0.0015	0.0102	0.0032	0.0005	0.0037	0.0161	0.0091	0.0165	0.0080	0.0233	0.0255	0.0255	0.0255	0.0255
1	1.1331	0.2440	0.3445	0.1572	0.1312	0.1824	0.3616	0.2439	0.3137	0.1985	0.5714	0.3987	0.3987	0.3987	0.3987
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	0.4042	1.5270	1.9345	2.0165	1.8703	1.6972	2.5207	2.5912	1.9734	2.2710	1.9233	1.6570	1.6570	1.6570	1.6570
4	1.3620	0.8445	1.0105	0.8704	0.8192	0.8273	1.1428	1.0585	0.9926	0.9561	1.1980	1.0000	1.0000	1.0000	1.0000
5	1.3620	0.8445	1.0105	0.8704	0.8192	0.8273	1.1428	1.0585	0.9926	0.9561	1.1980	1.0000	1.0000	1.0000	1.0000

Fitted Selection Pattern

AGE	2006	2007	2008	2009	2010
0	0.0255	0.0255	0.0255	0.0255	0.0255
1	0.3987	0.3987	0.3987	0.3987	0.3987
2	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.6570	1.6570	1.6570	1.6570	1.6570
4	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000

STOCK SUMMARY

Year	Recruits Age 0 thousands	Total Biomass tonnes	Spawning Biomass tonnes	Landings tonnes	Yield /SSB ratio	Mean F Ages 2- 3	SoP (%)
1991	27593470	111671	70281	24900	0.3543	0.4732	99
1992	32854260	110871	55019	19700	0.3581	1.7316	100
1993	43567120	134070	60006	13800	0.2300	1.1389	100
1994	52021700	156348	104326	18219	0.1746	1.4385	99
1995	74587110	201353	126766	21746	0.1715	1.1069	100
1996	69697330	227641	157944	27778	0.1759	0.7589	99
1997	69692890	246598	176905	27963	0.1581	0.5931	100
1998	85333250	294466	209133	38117	0.1823	0.7414	99
1999	185738300	380505	194767	39152	0.2010	0.6665	98
2000	169680800	568424	398743	41769	0.1048	0.6622	100
2001	138628230	626886	488258	62587	0.1282	0.4986	100
2002	84128370	536876	452747	69894	0.1544	0.5276	99
2003	79019160	395722	316703	62716	0.1980	0.7167	99
2004	80372320	321159	240786	54574	0.2266	0.6458	100
2005	85308970	322998	237689	56854	0.2392	0.8998	100
2006	115344950	349047	233702	39048	0.1671	0.6415	100
2007	169901890	474436	304534	39008	0.1281	0.4697	99
2008	160112110	545982	385870	51463	0.1334	0.4489	99
2009	155384560	568624	413240	91376	0.2211	0.8415	100
2010	207636610	530294	322657	91594	0.2839	1.0049	100

No of years for separable analysis : 9
Age range in the analysis : 0 . . . 5
Year range in the analysis : 1991 . . . 2010
Number of indices of SSB : 0
Number of age-structured indices : 4

Parameters to estimate : 40
Number of observations : 209

Conventional single selection vector model to be fitted.

PARAMETER ESTIMATES

Parm. No.		Maximum Likelh. Estimate	CV (%)	Lower 95% CL	Upper 95% CL	-s.e.	+s.e.	Mean of Param. Distrib.
Separable model : F by year								
1	2002	0.3971	22	0.2535	0.6220	0.3159	0.4993	0.4077
2	2003	0.5395	21	0.3574	0.8143	0.4372	0.6656	0.5515
3	2004	0.4862	21	0.3194	0.7399	0.3924	0.6023	0.4974
4	2005	0.6773	20	0.4563	1.0053	0.5537	0.8285	0.6912
5	2006	0.4829	21	0.3157	0.7386	0.3888	0.5998	0.4944

```
    6   2007      0.3536  22    0.2265    0.5520    0.2817    0.4438    0.3628
    7   2008      0.3379  22    0.2173    0.5254    0.2697    0.4232    0.3466
    8   2009      0.6334  20    0.4230    0.9485    0.5155    0.7783    0.6470
    9   2010      0.7565  28    0.4317    1.3255    0.5682    1.0071    0.7881

 Separable Model: Selection (S) by age
   10      0      0.0255  25    0.0156    0.0417    0.0199    0.0328    0.0263
   11      1      0.3987  18    0.2757    0.5766    0.3303    0.4813    0.4058
           2      1.0000     Fixed : Reference Age
   12      3      1.6570  15    1.2320    2.2285    1.4245    1.9274    1.6760
           4      1.0000     Fixed : Last true age

 Separable model: Populations in year 2010
   13      0  207636614  67   55302670 779581940 105721226 407798555 260757557
   14      1   80619755  29   45508643 142820009  60218998 107931800  84125056
   15      2   25146246  22   16333372  38714216  20177265  31338921  25763071
   16      3    6159966  21    4071169   9320463   4986702   7609274   6299022
   17      4     753664  25     455564   1246828    582952    974368    778938

Separable model: Populations at age
   18   2002      779670  35     387926   1567012    546055   1113230    830719
   19   2003     1910607  27    1120955   3256525   1455515   2507991   1982640
   20   2004     1167355  25     701535   1942478    900263   1513687   1207425
   21   2005      932878  24     579874   1500779    731934   1188989    960735
   22   2006      410118  25     248280    677448    317469    529806    423787
   23   2007      446919  24     275692    724492    349289    571837    460702
   24   2008      634713  22     404792    995229    504558    798443    651649
   25   2009      846193  22     548457   1305557    678242   1055734    867158


 Age-structured index catchabilities
                                        Bul

 Linear model fitted. Slopes at age :
   26   1  Q  .2089E-02  20 .1724E-02 .3775E-02 .2089E-02 .3116E-02 .2602E-02
   27   2  Q  .7358E-02  20 .6069E-02 .1333E-01 .7358E-02 .1099E-01 .9176E-02
   28   3  Q  .1052E-01  20 .8641E-02 .1931E-01 .1052E-01 .1586E-01 .1319E-01
   29   4  Q  .6265E-02  21 .5098E-02 .1183E-01 .6265E-02 .9627E-02 .7947E-02


                                        Ukr

 Linear model fitted. Slopes at age :
   30   1  Q  .4692E-02  20 .3872E-02 .8481E-02 .4692E-02 .6999E-02 .5846E-02
   31   2  Q  .1094E-01  20 .9026E-02 .1982E-01 .1094E-01 .1635E-01 .1365E-01
   32   3  Q  .2008E-01  20 .1649E-01 .3686E-01 .2008E-01 .3027E-01 .2518E-01
   33   4  Q  .7184E-02  21 .5845E-02 .1357E-01 .7184E-02 .1104E-01 .9112E-02


                                        Bul survey

 Linear model fitted. Slopes at age :
   34   1  Q  .1039E-02  42 .6916E-03 .3643E-02 .1039E-02 .2425E-02 .1737E-02
   35   2  Q  .4768E-02  42 .3180E-02 .1664E-01 .4768E-02 .1109E-01 .7951E-02
   36   3  Q  .1625E-01  43 .1071E-01 .5867E-01 .1625E-01 .3869E-01 .2754E-01
   37   4  Q  .9492E-02  45 .6150E-02 .3618E-01 .9492E-02 .2344E-01 .1652E-01


                                        Rom survey

 Linear model fitted. Slopes at age :
   38   1  Q  .1321E-02  37 .9235E-03 .3987E-02 .1321E-02 .2787E-02 .2057E-02
   39   2  Q  .3665E-02  37 .2566E-02 .1100E-01 .3665E-02 .7700E-02 .5691E-02
```

RESIDUALS ABOUT THE MODEL FIT

Separable Model Residuals

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	-0.411	0.409	-0.499	-0.715	0.103	1.037	0.246	-0.167	0.000
1	-0.016	0.013	0.371	-0.081	0.164	0.037	0.063	-0.003	-0.558
2	0.212	-0.208	0.013	0.060	-0.159	-0.396	-0.166	-0.197	-0.248
3	-0.010	0.004	0.263	0.038	-0.213	-0.096	0.182	0.261	0.340
4	0.069	0.229	-0.078	0.176	-0.140	0.248	0.334	0.316	0.145

AGE-STRUCTURED INDEX RESIDUALS

Bul

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	-1.032	-0.545	-0.167	0.174	0.148	0.622	-0.229	-0.181	-0.230	0.367	0.511	0.214	0.338	-0.107	-0.330
2	1.375	0.725	0.145	-0.626	0.225	-0.423	0.203	-0.795	-0.477	-0.255	0.106	-0.096	-0.131	-0.363	-0.104
3	2.230	1.110	0.540	-0.372	-1.012	-1.090	-0.731	-1.675	-0.739	-0.503	-0.184	0.073	-0.397	-0.216	0.985
4	1.046	0.734	1.002	-0.067	-0.701	-1.664	-1.000	-2.040	-0.762	-0.532	0.307	-0.680	0.627	0.303	0.881

Bul

Age	2009	2010
1	0.269	0.179
2	0.093	0.400
3	0.549	1.434
4	0.912	1.636

Ukr

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.701	0.065	0.020	-0.550	-0.530	-0.224	-0.203	-0.200	-0.211	-0.412	0.142	0.062	0.431	-0.251	0.162
2	1.243	1.083	0.879	-0.448	-0.020	0.206	0.559	-0.521	0.124	-0.493	-0.454	0.328	0.046	-1.201	-0.737
3	0.880	0.711	-0.109	-0.492	0.518	0.374	0.981	-0.439	-0.113	-0.215	0.195	0.256	0.136	-0.486	0.037
4	1.638	0.062	0.986	-0.030	0.634	-1.173	1.173	0.195	0.487	0.511	0.213	0.998	0.559	-2.817	0.248

Ukr

Age	2009	2010
1	0.444	0.554
2	-0.038	-0.555
3	-0.093	-2.140
4	-1.427	-2.255

Bul survey

Age	2007	2008	2009	2010
1	-0.626	-0.197	0.145	0.678
2	-0.134	-0.224	-0.151	0.509
3	0.146	-0.816	0.197	0.473
4	-0.794	-1.074	0.968	0.900

Rom survey

Age	2007	2008	2009	2010
1	-0.805	0.056	-0.117	0.865
2	-0.016	0.053	0.373	-0.410

PARAMETERS OF THE DISTRIBUTION OF ln(CATCHES AT AGE)

Separable model fitted from 2002 to 2010	
Variance	0.1387
Skewness test stat.	0.7387
Kurtosis test statistic	0.6430
Partial chi-square	0.1960
Significance in fit	0.0000
Degrees of freedom	20

PARAMETERS OF THE DISTRIBUTION OF THE AGE-STRUCTURED INDICES

DISTRIBUTION STATISTICS FOR Bul

Linear catchability relationship assumed

Age	1	2	3	4
Variance	0.0429	0.0683	0.2587	0.2696
Skewness test stat.	-1.2623	1.5708	0.8860	-0.6461
Kurtosis test statisti	0.3208	0.8715	-0.3010	-0.6994
Partial chi-square	0.0646	0.1058	0.4708	0.6253
Significance in fit	0.0000	0.0000	0.0000	0.0000
Number of observations	17	17	17	17
Degrees of freedom	16	16	16	16
Weight in the analysis	0.2500	0.2500	0.2500	0.2500

DISTRIBUTION STATISTICS FOR Ukr

Linear catchability relationship assumed

Age	1	2	3	4
Variance	0.0348	0.1123	0.1266	0.3723
Skewness test stat.	0.5258	0.4823	-2.3849	-1.7704
Kurtosis test statisti	-0.7342	-0.5422	2.4862	0.1546
Partial chi-square	0.0478	0.1652	0.2018	0.8531
Significance in fit	0.0000	0.0000	0.0000	0.0000
Number of observations	17	17	17	17
Degrees of freedom	16	16	16	16
Weight in the analysis	0.2500	0.2500	0.2500	0.2500

DISTRIBUTION STATISTICS FOR Bul survey

Linear catchability relationship assumed

Age	1	2	3	4
Variance	0.0759	0.0292	0.0792	0.2943
Skewness test stat.	0.1169	0.9050	-0.7542	-0.0254
Kurtosis test statisti	-0.5035	-0.2853	-0.3276	-0.7975
Partial chi-square	0.0214	0.0081	0.0230	0.1101
Significance in fit	0.0008	0.0002	0.0009	0.0094
Number of observations	4	4	4	4
Degrees of freedom	3	3	3	3
Weight in the analysis	0.2500	0.2500	0.2500	0.2500

DISTRIBUTION STATISTICS FOR Rom survey

Linear catchability relationship assumed

Age	1	2
Variance	0.1570	0.0344
Skewness test stat.	0.1214	-0.1593
Kurtosis test statisti	-0.4232	-0.4173
Partial chi-square	0.0434	0.0097
Significance in fit	0.0024	0.0003
Number of observations	4	4
Degrees of freedom	3	3
Weight in the analysis	0.3333	0.3333

ANALYSIS OF VARIANCE

Unweighted Statistics

Variance

	SSQ	Data	Parameters	d.f.	Variance
Total for model	99.5562	209	40	169	0.5891
Catches at age	3.9107	45	25	20	0.1955
Aged Indices					
Bul	40.9360	68	4	64	0.6396
Ukr	41.3433	68	4	64	0.6460
Bul survey	5.7430	16	4	12	0.4786
Rom survey	7.6232	12	3	9	0.8470

Weighted Statistics

Variance

	SSQ	Data	Parameters	d.f.	Variance
Total for model	9.1234	209	40	169	0.0540
Catches at age	2.7750	45	25	20	0.1387
Aged Indices					
Bul	2.5585	68	4	64	0.0400
Ukr	2.5840	68	4	64	0.0404
Bul survey	0.3589	16	4	12	0.0299
Rom survey	0.8470	12	3	9	0.0941

7.1.5 Short term prediction of stock biomass and catch

7.1.5.1 Justification

A deterministic short term prediction of stock size and catch was conducted based on ICA results.

7.1.5.2 Input parameters

The input parameters are listed in the Table 6.1.5.2.1 below. They do represent short term averages of the ICA inputs. The exploitation pattern used is the 2010 estimated vector rescaled to the average exploitation patterns estimated for the years 2008-2010. Due to the poor fit between the recruitment and survey index age 0 was set using the geometric mean from 2008-2010.

As the fishery for sprat in the Black Sea is not constrained by an international TAC, the intermediate year 2011 was defined as a status quo effort year with unchanged fishing mortality.

Table 6.1.5.2.1. Sprat in the Black Sea. Input to short term prediction.

2011

age	stock size (000)	M	maturity	weight in stock (kg)	exploitation pattern	weight in catch (kg)
0	172832224	0.6400	0.0000	0.001	0.0151	0.0021
1	107930000	0.9500	1.0000	0.0025	0.2454	0.0029
2	24790000	0.9500	1.0000	0.0035	0.5240	0.0044
3	5440000	0.9500	1.0000	0.0045	1.0004	0.0065
4	910000	0.9500	1.0000	0.0071	0.5833	0.008
5	230000	0.9500	1.0000	0.016	0.5833	0.01

2012

age	stock size (000)	M	maturity	weight in stock (kg)	exploitation pattern	weight in catch (kg)
0	172832224	0.6400	0.0000	0.001	0.0151	0.0021
1		0.9500	1.0000	0.0025	0.2454	0.0029
2		0.9500	1.0000	0.0035	0.5240	0.0044
3		0.9500	1.0000	0.0045	1.0004	0.0065
4		0.9500	1.0000	0.0071	0.5833	0.008
5		0.9500	1.0000	0.016	0.5833	0.01

2013

age	stock size (000)	M	maturity	weight in stock (kg)	exploitation pattern	weight in catch (kg)
0	172832224	0.6400	0.0000	0.001	0.0151	0.0021
1		0.9500	1.0000	0.0025	0.2454	0.0029
2		0.9500	1.0000	0.0035	0.5240	0.0044
3		0.9500	1.0000	0.0045	1.0004	0.0065
4		0.9500	1.0000	0.0071	0.5833	0.008
5		0.9500	1.0000	0.016	0.5833	0.01

7.1.5.3 Results

The following Tabl. 6.1.5.3.1 lists the single option status quo results of the prediction with stock parameters at age for 2011 to 2013.

Table 4.1.7.3.1. Sprat in the Black Sea. Single option (status quo) short term prediction.

2011	F-factor:	1	reference F1-3	0.5899		1 January	
age	absolute F	catch in numbers (000)	catch in weight (t)	stock size (000)	stock biomass (t)	sp. stock size (000)	sp. stock biomass (t)
0	0.0151	1909620	4010	172832224.2	172832	0	0
1	0.2454	15454784	44819	107930000	269825	107930000	269825
2	0.5240	6794313	29895	24790000	86765	24790000	86765
3	1.0004	2393430	15557	5440000	24480	5440000	24480
4	0.5833	271480	2172	910000	6461	910000	6461
5	0.5833	68616	686	230000	3680	230000	3680
		26892243	97139	312132224	564043	139300000	391211
2012	F-factor:	1	reference F1-3	0.5899		1 January	
age	absolute F	catch in numbers (000)	catch in weight (t)	stock size (000)	stock biomass (t)	sp. stock size (000)	sp. stock biomass (t)
0	0.0151	1909620	4010	172832224	172832	0	0
1	0.2454	12854538	37278	89770927	224427	89770927	224427
2	0.5240	8950295	39381	32656403	114297	32656403	114297
3	1.0004	2497802	16236	5677226	25548	5677226	25548
4	0.5833	230811	1846	773677	5493	773677	5493
5	0.5833	58590	586	196392	3142	196392	3142
		26501656	99337	301906849	545739	129074625	372907
2013	F-factor:	1	reference F1-3	0.5899		1 January	
age	absolute F	catch in numbers (000)	catch in weight (t)	stock size (000)	stock biomass (t)	sp. stock size (000)	sp. stock biomass (t)
0	0.0151	1909620	4010	172832224	172832	0	0
1	0.2454	12854538	37278	89770927	224427	89770927	224427
2	0.5240	7444420	32755	27162008	95067	27162008	95067
3	1.0004	3290409	21388	7478733	33654	7478733	33654
4	0.5833	240876	1927	807415	5733	807415	5733
5	0.5833	49813	498	166972	2672	166972	2672
		25789676	97856	298218279	534385	125386055	361553

The *status quo* fishing in 2011 would result in landings 97 139t, and SSB of 391 211 t, which are of similar size with landings 91 594 t and SSB - 324 938 t in 2010. The status quo model predicts increased catches of 99 337 t and 97 856 t, with the SSB decreasing to 372 907 t and 361 553 t in 2012 and 2013 respectively.

Recruitment estimates in 2008 and 2009 are rather imprecise due to the lack of survey data. Recruitment however seems to have entered in an increasing trend after 2006. In short-term forecast we used a geometric mean over 2008-2010 equal of 172 832 224 000.

Catches have been very high in the last two years due to quickly expending Turkish fishery. Under the status quo F assumption, catches are expected to increase in 2012, and in 2013 keeping the level of 2011.

Given that the state of the stock depends greatly on a variable recruitment, the dynamic nature of developing Turkish sprat fishery and the lack of quota constraints on the sprat fisheries, the status quo assumption must be taken with a caution when considered in management advice. However, the sprat stock looks healthy at present, and able to cope with present fishing pressure.

More management options through multiplications of the fishing mortality are given in the following Table 4.1.7.3.2.

Table 4.1.7.3.2. Sprat in the Black Sea. Management option table (status quo in 2011) providing short term prediction.

2011					2012					2013	
F-factor	reference F	stock biomass	sp. stock biomass	catch in weight	F-factor	reference F	stock biomass	sp. stock biomass	catch in weight	stock biomass	sp. stock biomass
1.0000	0.5899	564043	391211	97139	0.0000	0.0000	546235	373403	0	600339	427507
					0.1000	0.0588	546235	373403	11823	592350	419518
					0.2000	0.1177	546235	373403	23163	584741	411909
					0.3000	0.1765	546235	373403	34042	577487	404655
					0.4000	0.2353	546235	373403	44491	570565	397733
					0.5500	0.3236	546235	373403	59402	560765	387933
					0.6000	0.3530	546235	373403	64182	557645	384813
					0.7000	0.4118	546235	373403	73470	551608	378776
					0.8000	0.4706	546235	373403	82412	545831	372999
					0.9000	0.5295	546235	373403	91029	540301	367469
					1.0000	0.5883	546235	373403	99337	535001	362169
					1.1000	0.6471	546235	373403	107353	529919	357087
					1.2000	0.7059	546235	373403	115089	525042	352210
					1.3000	0.7648	546235	373403	122562	520363	347531
					1.4000	0.8236	546235	373403	129782	515865	343033
					1.5000	0.8824	546235	373403	136765	511543	338711

7.1.6 Medium term prediction of stock biomass and catch

The WG did not undertake medium term projections.

7.1.7 Long term predictions

Fmax could not be estimated due to shape to the YpR curve, which has a maximum well outside of the reasonable range. The skewed shape of the YpR curve results from the high natural mortality and the short life span of sprat in the Black Sea. Due to such effects, STECF EWG 11-16 on Black Sea does not consider $F_{0.1}$ as an appropriate management reference point, and proposes a limit reference point of exploitation rate E≤0.4 which implies Fmsy=0.64. Given that the mean F=0.59 yields an exploitation rate of about E=0.38 (natural mortality M=0.95), the WG considers the stock of sprat in the Black Sea as sustainably exploited.

7.1.8 Scientific advice

7.1.8.1 Short term considerations

The WG accepted the current ICA assessment as adequately presenting the state and dynamics of the stock and the development of the fisheries.

State of the spawning stock size: According to the present assessment in recent years the SSB ranges at medium to high levels: in the range of 300 - 400 000 t. Under a constant recruitment scenario and status quo F, SSB is expected to stay at the approximate same level by 2013.

State of recruitment: After a positive trend in 1999-2001 the recruitment has decreased in 2002-2004 and increased again since 2006. Recruitment estimates in 2008 and 2009 are rather imprecise due to the lack of survey data. In short-term forecast we used a geometric mean over 2008-2010 average value of 172 832 224 000.

State of exploitation: Over the last few years the fishing mortality has piqued in 2005 and 2009 at a level of about F=0.59. This equals an exploitation rate of about E=0.38 (natural mortality M=0.95). Proposing a limit reference point of exploitation rate E≤0.4, the WG considers the stock of sprat in the Black Sea as sustainably exploited. Status quo fishing implies catches in the range of 90 000 to 100 000 t over 2011 - 2013.

7.1.8.2 Medium term considerations

Due to the cyclic nature of recruitment and unknown dependence on environmental conditions the WG is not able to provide medium term forecast. After medium-to-high recruitment and relatively strong exploitation the stock is now at a relatively level. Short term fluctuations, possibly environmentally driven, and unregulated fishing pressure, may cause sudden shifts, as the collapse in 1990.

7.2 Turbot in the Black Sea

7.2.1 Biological features

7.2.1.1 Stock Identification

Turbot (*Psetta maxima*) occurs all over the shelf area of all Black Sea coastal states at depths up to 100 m - 140 m, grouped in local shoals. Species habitats are sandy and mixed bottoms or mussel beds. Turbot in the Black Sea is represented by several local populations mixing in the adjacent zones. Local populations are independent units of the stock, and it is especially important to cover them all in order to provide an accuarate assessessment of the stock. This is very difficult in practice, due to numerous gaps of information; therefore the present assessment is based on the analysis of combined fisheries data of all Black Sea countries.

7.2.1.2 Growth

Turbot is a long living species with a slow growth rate. The parameters reported here by countries are considered appropriate for the description of an average growth performance of the species in GSA 29 – Tab. 1.2.2.1.

Table 6.2.1.1.1 Growth parameters of turbot by countries.

COUNTRY	AREA	YEAR_PERIOD	SPECIES	SEX	L_INF	K	t_0	A	B
ROM	29	2003-2005	TUR	C	80.98	0.15	-1.37	0.000018	3.01
ROM	29	2006-2008	TUR	C	72.5	0.212	-1.15	0.00806	3.22
ROM	29	2009-2011	TUR	C	86.3	0.19	-2.1	0.030088	2.87
BGR	29	2007-2008	TUR	C	77.81	0.242	0.152	0.000431	2.21
BGR	29	2008-2009	TUR	C	120.40	0.076	-2.811	0.000011	3.13
BGR	29	2008-2009	TUR	F	129.81	0.065	-3.351	0.000013	3.11
BGR	29	2008-2009	TUR	M	67.38	0.246	-1.217	0.000041	2.78
BGR	29	2007-2008	TUR	M	57.60	0.507	0.458	0.000918	1.96
BGR	29	2007-2008	TUR	F	80.31	0.213	-0.136	0.000424	2.22
BGR	29	2006-2007	TUR	M	77.49	0.158	-1.975	0.000022	2.92
BGR	29	2006-2007	TUR	F	124.27	0.080	-2.136	0.000021	2.94
BGR	29	2006-2007	TUR	C	79.26	0.173	-1.561	0.000008	3.17
UKR (NE)	29	2000 - 2006	TUR	C				0.000216	2.48
UKR (NW)	29	2008 - 2009	TUR	C	74	0.106	-1.73	0.001437	1.94
TR	29	1990 - 1991	TUR	C	82.57	0.17	-0.93	0.0085	3.18
TR	29	1990 - 1996	TUR	C	96.24	0.119	-0.01	0.0112	3.12
TR	29	1998 - 2000	TUR	C	95.9	0.104	-1.55	0.0106	3.14
BGR-RO	29	2010	TUR	C	79.578	0.237	-0.104	0.000242	2.361
TR	29	2010	TUR	C	60.57	0.218	0.25	0.12	3.081

7.2.1.3 Maturity

The species reaches sexual maturity at ages between 3 and 5. A new maturity ogive was prepared based on historical Bulgarian data for 1970-2006. For the period 2006 – 2010, maturity ogives data by countries were averaged by age groups. The accepted proportions of mature individuals by age groups for the period 1970 – 2010 are given in Table 6.2.1.3.1.

Table 6.2.1.3.1. Common maturity ogive of turbot by ages and years.

Year/Age	1	2	3	4	5	6	7	8	9	10+
1970-2006	0	0	0.75	1	1	1	1	1	1	1
2007	0	0	0.38	0.61	1	1	1	1	1	1
2008	0	0	0.51	0.76	1	1	1	1	1	1
2009	0	0	0.41	0.67	1	1	1	1	1	1
2010	0	0	0.22	0.83	1	1	1	1	1	1

7.2.2 Fisheries

7.2.2.1 General description

The STECF EWG 11 16 Black Sea noted that turbot (Psetta maxima) is the one of the most important demersal fish species in the Black Sea with high market demand and prices. Main fishing gear for all coastal states are gillnets, but in Turkey, the bottom trawling is also permitted. The turbot is often caught as a by-catch of sprat fishery, long lines and purse seiners fishery. Turbot catches are higher in spring and autumn periods: March – April and October – November for Bulgaria and Romania; May – June for Ukraine, March - April and September – October for Turkey. Annual landings during last 5 years range between 730 and 1035 t. Misreporting and illegal catches also occur.

7.2.2.2 Management regulations applicable in 2010 and 2011

The quotas allocation of turbot in 2011 to the Member States was introduced regarding to Council Regulations (EC) No 1256/2010. Both for Bulgaria and Romania quotas of 43.2 t in 2011 for each country were permitted. Prohibition of fishing activity during reproduction period for turbot was in force from 15 April to 15 June in European Community waters of the Black Sea. The minimum legal mesh size for bottom-set nets used to catch turbot should be 400 mm.

In Ukraine Turbot fisheries is conducted with bottom (turbot) gill nets with minimum mesh size 180 - 200 mm. The use of bottom trawls has been prohibited. Turbot exploitation in Ukraine has been regulated by TACs since 1996.

The Regulations of Fisheries in Ukraine determine the following standards regulating the fisheries of the Black Sea turbot:

- minimum commercial fishing size – 35 cm (SL);
- allowable by-catch of its juveniles – during the non-target fisheries not more than 2% of total catch weight, during the target fisheries with nets (with mesh size 180 mm) not more 5% by counting;
- during target long-lining of picked dogfish and Rajiformes by-catch of turbots is allowed, at the amount of not more than 20% of its juveniles by counting;
- turbot by-catch is allowed in trawl catches of sprat not more than 4 individuals a commercial fishing length per one ton of catch;
- in the period of abundant spawning of turbot in the coastal 12-mile zone a temporal prohibition for 15 – 30 days is implemented for harvesting of fish with trawls, net and long-lines (such prohibition may be imposed gradually).

In Turkey turbot target fishing is conducted with bottom (turbot) gill nets with minimum mesh size 160 – 200 mm (Tonay, Öztürk, 2003) and with bottom trawls with minimum mesh size 40 mm. The minimum admissible landing size in Turkey is 40 cm total length. In Turkey – no TAC regulation of turbot catches. Seasonal fishing closures in Turkey are: for bottom trawls from 1st September – 15th April and for gillnets – from 1th May up to 30th June.

7.2.2.3 Catches

7.2.2.3.1 Landings

Landings data for Bulgaria and Romania were reported to STECF EWG 11 16 Black Sea through the EU Data collection program and for the Turkey and Ukraine – according to the official statistics of each country. Since 2002 total annual landings varied between 618 and 1035 tons (Tab. 6.2.2.3.1.1). The data set of landings by countries was compiled for the period 1989 – 2010.

Table 6.2.2.3.1..1 Landings of turbot in the Black Sea during the period 1989 – 2010.

Year	Bulgaria	Romania	Ukraine west	Ukraine east	Turkey west	Turkey east	Russian Federation	Georgia	Black Sea total	Black Sea west
1989	0.9	0	2	0	448	1001	0	8	1459.9	450.9
1990	0	0	9	0	908	475	0	1	1393	917
1991	0	2	17.1	0.9	600	315	0	0	935	619
1992	0	1	18	1	308	110	1	0	439	327
1993	0	6	10	0	400	1185	2	0	1603	416
1994	0	6	18	1	1293	821	5	0	2144	1317
1995	60	4	10	0	2006	844	19	0	2943	2080
1996	62	6	37	2	1414	510	17	0	2048	1519
1997	60	1	40	2	777	134	11	0	1025	878
1998	64	0	40	2	1056	412	14	0	1588	1160
1999	54	2	69	4	1579	225	15	5	1953	1704
2000	55.1	2	76	4	2321	318	4	9	2789.1	2454.1
2001	56.5	13	123	6	2169	154	24	11	2556.5	2361.5
2002	135.5	16.681	99	5.47	193	142	15	11	617.651	444.5
2003	40.8	23.978	118	5.876	126	93	15	1	423.654	308.8
2004	16.2	42.031	126	7.157	118	116	1.7	7	434.088	302.2
2005	12.69	36.53	123	6	273	275	7.5	7	740.72	445.69
2006	14.81	35.108	154	8	266	481	7.6	0	966.518	466.81
2007	66.852	48.064	205	10.58	346	353	5.7	0	1035.396	666
2008	54.621	47.112	239	12.35	224	234	4.7	0	815.786	565
2009	52.47	48.767	247	16	223	119	24.3	0	730.537	571
2010	46.45	48.25	166.00	41.00	218.00	77.00	25	0	621.70	479

7.2.2.3.2 Discards

No data from discards surveys have been reported to STECF EWG 11-16 Black Sea.

7.2.2.4 Fishing effort

Fishing effort data for Bulgaria and Romania (Table 6.2.2.4.1) were reported to EWG 11 16 Black Sea through the Data collection program.

Table 6.2.2.4.1 DCF Nominal fishing effort (kW days at sea) by nation, gear and year.

AREA	COUNTRY	GEAR	2008	2009	2010
SA 29	BUL	-1	18573751	15363673	25526826
SA 29	BUL	GNS	15666852	36979225	55479310
SA 29	BUL	OTM	6128829	9918196	11860801
SA 29	ROM	FPN	75773	118771	105152
SA 29	ROM	GNS	3247650	3991915	3640469
SA 29	ROM	OTM	212604	10520	662

Table 6.2.2.4.2. Fishing effort data for Romania in 2010.

Transversal and economic variables on fishing gears type	**TUR gill nets**		
	Boats of 6 – 12 m	**Boats < 6 m**	**Total boats**
Number of boats	111	3	114
Average length of boats (m)	7.54	4.93	7.47
Average age of boats (years)	13	17	13
No. fishing gears (pieces)	3612	79	3691
Gill nets length (m)	65/100	100	65/100
Water depth in the working area (m)	17/70	20/45	17/70
No. of trips	628	20	648
No. of fishing months	98	8	106
Soaking time (days)	2435	73	2508
No. fisherman	243	6	249
No. fishing days	628	20	648
GT_{total}	134.10	1.37	130.0034
GT fishing days	84214.80	27.4	84242.20
KW_{total}	1476.72	35.94	1432.25
KW fishing days	927380.16	718.80	928098.96
Total catch (kg)	46448	1800	48248
Landings (kg)	46448	1800	48248
Discards (kg)	-	-	-
Landing value (lei)	934998.24	36234	971232.24

No data were available for fishing effort and CPUE from Ukraine.

The number of fishing vessels, operating in Turkish Black Sea area on turbot are given in Table 6.2.4.2.3.

Table 6.2.4.2.3. Number of Turkish fishing vessels, operating on turbot fisheries in the Black Sea area.

Year	Vessels (in Nbs)
1987	102
1988	89
1989	96
1990	223
1991	94
1992	273
1993	286
1994	204
1995	166
1996	298
1997	266
1998	264
1999	338
2000	340
2001	286
2002	300
2003	133
2004	141
2005	212
2006	231
2007	206
2008	263
2009	237
2010	225

7.2.2.5 Commercial CPUE

Table 6.2.2.5.1. CPUE data for Bulgaria (2008 – 2010).

Country	***Species***	***Metier***		***CPUE***[1]		
		Gear	***Gear***	***2008***	***2009***	***2010***
Bulgaria	***Turbot TUR***	GNS	LOA > 0 < 6	30.4	32.5	21.86
			LOA => 6<12	58.32	53.91	34.5
			LOA => 12<18	125.26	71.62	65.48
			LOA => 18<24	83.05	95.86	102.95
			LOA => 24<40	--	--	250

7.2.3 Scientific Surveys

7.2.3.1 Method 1: International (Bulgarian and Romanian) Bottom Trawl Survey

Based on the DCF data call, abundance and biomass indices were calculated for the Bulgarian (Panayotova et.al. 2010, 2011) and Romanian waters (Maximov et al, 2010, 2011) in spring and autumn seasons by swept area method. In the Black Sea the following number of hauls was reported per depth stratum (Tab. 6.2.3.1.1).

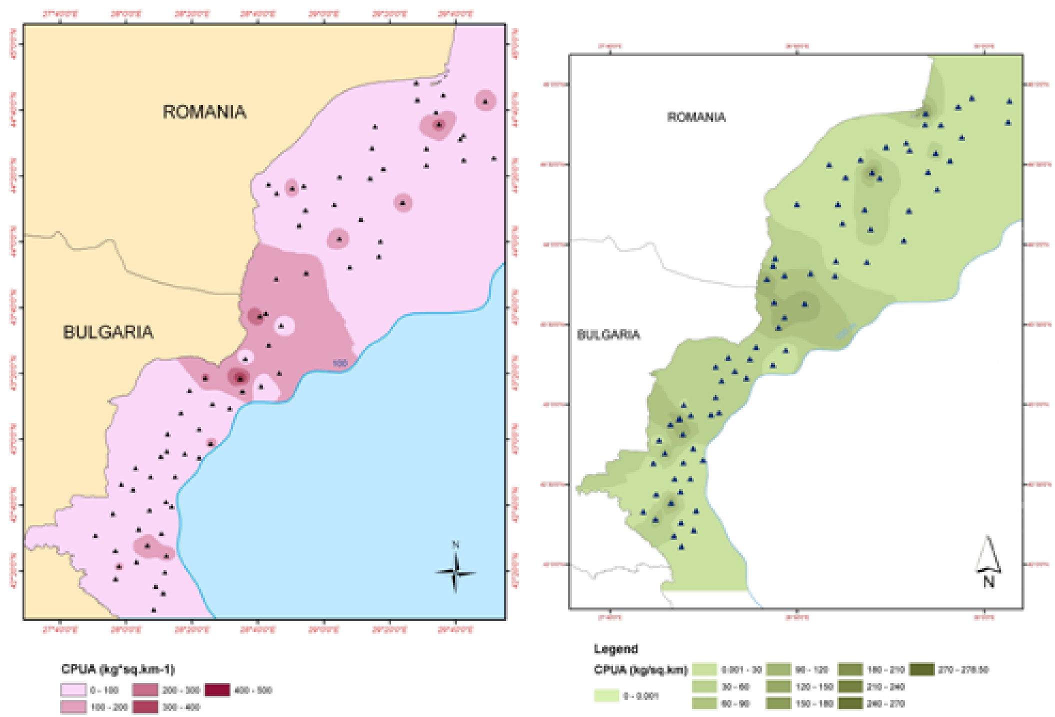
Table 6.2.3.1.1. Number of hauls per depth stratum by seasons in 2010.

Country	Period	Stratum	Number of hauls
BG	May-June	15 - 35 m	4
		35 - 50 m	10
		50 - 75 m	15
		75 - 100 m	14
	November -	15 - 35 m	5
		35 - 50 m	9
		50 - 75 m	16
		75 - 100 m	10
ROU	May	15 - 35 m	9
		35 - 50 m	12
		50 - 75 m	12
	October -	15 - 35 m	7
	November	35 - 50 m	14
		50 - 75 m	14

For estimation of abundance and biomass of turbot stocks in Bulgarian and Romanian waters swept area method and standard methodology for stratified sampling were used (Sparre, Venema, 1998; Sabatella,Franquesa, 2004). Since 2010, common Bulgarian - Romanian surveys were carried out with same fishing vessels and gear.

7.2.3.1.1 Geographical distribution patterns

Distribution of turbot CPUA in EU waters is shown on Fig. 6.2.3.1.1.1 (Panayotova et.al., 2010, 2011; Maximov et al, 2011.



A B

Figure 6.2.3.1.1.1. Distribution of turbot CPUA (kg/km^2) from surveys along the Bulgarian and Romanian Black Sea coast in spring (A) and autumn (B) seasons in 2010 (Panayotova et.al, 2010, 2011, Maximov et.al, 2010, 2011).

The following figure (Fig. 6.2.3.1.1.2) display the distribution of turbot by age groups in the Bulgarian and Romanian Black Sea in spring (A) and autumn (B) seasons in 2010 (Panayotova et.al., 2010, 2011; Maximov et al, 2010, 2011).

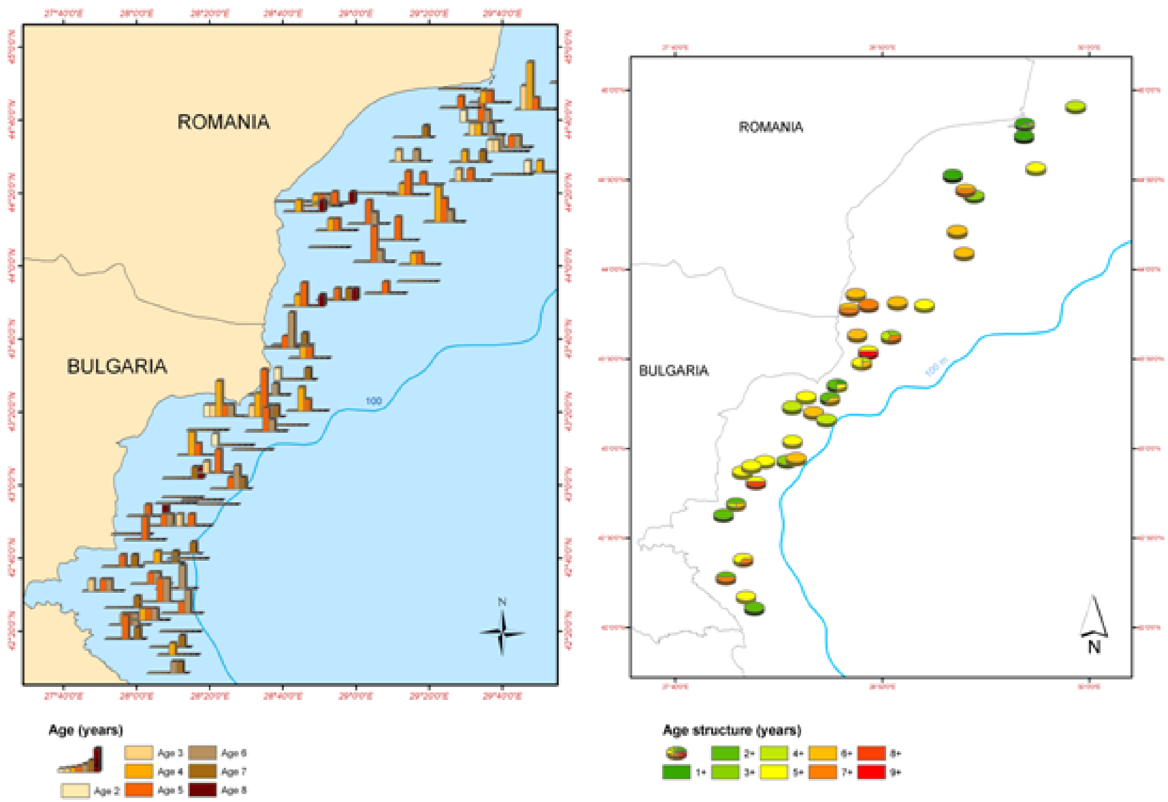


Fig. 6.2.3.1.1.2. Distribution of turbot by age groups in the Bulgarian and Romanian Black Sea in spring (A) and autumn (B) seasons in 2010.

7.2.3.1.2 Trends in abundance and biomass

Fishery independent information regarding the state of the turbot was derived from the national surveys in Bulgaria (Panayotova et.al., 2006, 2007a, 2007b, 2008a, 2008b, 2009, 2010, 2011) and Romania (Maximov et al, 2009; Maximov et al, 2010a, Maximov et al, 2010b; Radu et al, 2009a; Radu et al, 2009b, Radu et al, 2010a; Radu et al, 2010b, 2011). Fig. 6.2.3.1.2.1 shows the trends in the biomass index in Bulgaria and in Romania. The biomass indices show similar trends and values in the Bulgarian and in the Romanian areas. Decreasing trend after 2008 was observed.

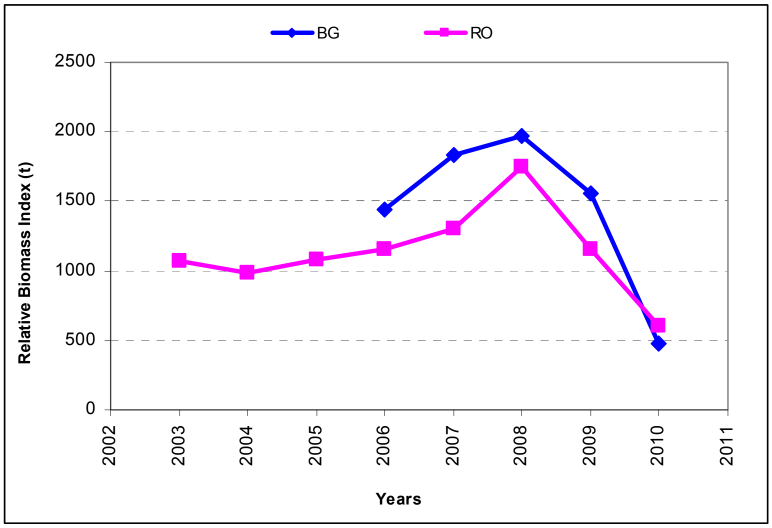
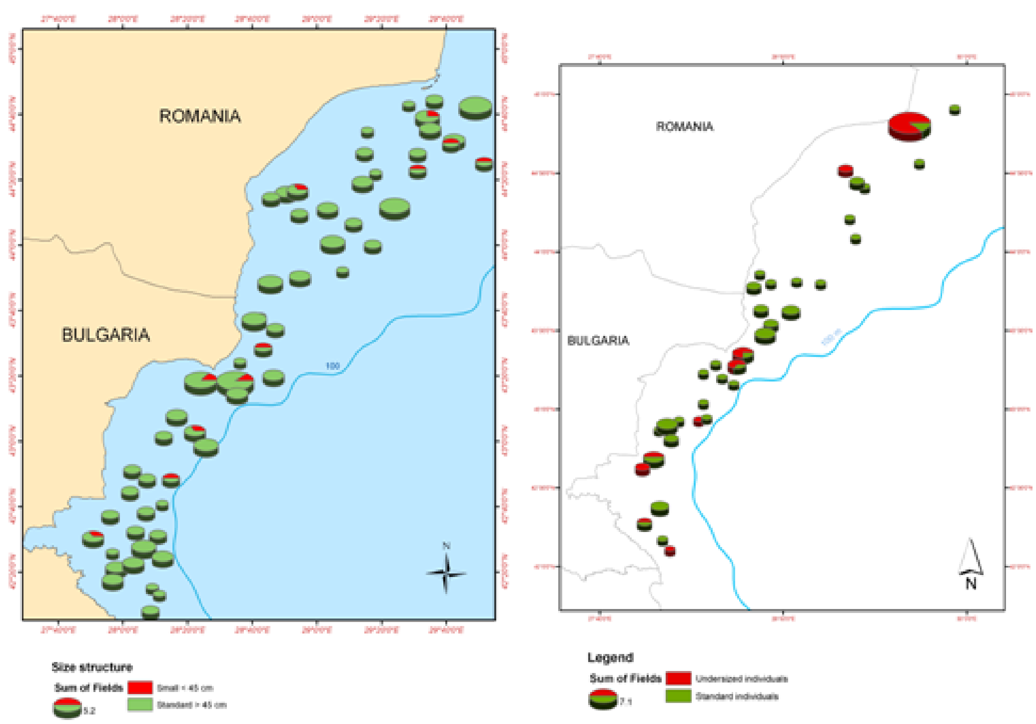


Fig. 6.2.3.1.2.1. Biomass indices derived from national surveys in Bulgaria and Romania) for turbot in the Black Sea in the period 2003 - 2010.

7.2.3.1.3 Trends in abundance at length or age

The species is distributed all along the continental shelf of the Black Sea (GFCM GSA 29), with the largest abundance in the depth range between 50 – 75 m. The species is concentrated in the coastal area up to 40 m during the spawning period in spring and after that spreads in the deeper waters for feeding (Fig. 6.2.3.1.2.1).

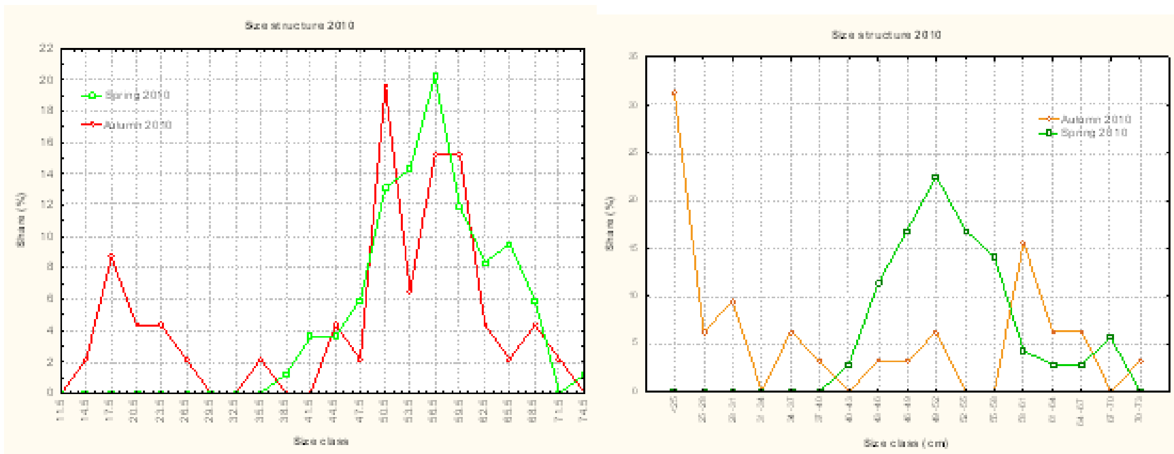


A B

Figure 6.2.3.1.2.1. Size distribution of turbot in spring 2010 (A) and autumn 2010 seasons (B) during the surveys in the Bulgarian and Romanian Black Sea area (Panayotova et.al, 2010, 2011; Maximov et.al., 2010, 2011).

7.2.3.1.4 Trends in growth

STECF EWG 11 16 Black Sea analyzed the available data of size composition from surveys in Bulgarian (Panayotova et.al., 2010, 2011) and Romanian waters (Maximov et al, 2010, 2011) - Fig. 6.2.3.1.4.1.



A B

Figure 6.2.3.1.4.1. Length frequency composition of turbot catches during the surveys in Bulgaria (A) and Romania (B) in 2010.

7.2.3.1.5 Trends in maturity

No analyses were conducted.

7.2.4 Assessment of historic parameters

7.2.4.1 Method 1: XSA

7.2.4.1.1 Justification

The data (1970-2010) of total landings, catch at ages, weights and maturity at age are considered appropriate for assesseng the stock using the XSA (FLR). Four tuning series (3 surveys and 1 commercial CPUE series were compiled from previous assessments (Daskalov et al., 2010) and recent data.

7.2.4.1.2 Input parameters

Recent data from national statistics by countries for the period 1989 – 2010 were added to the historic catch at age data set compiled during the previous meetings from Prodanov et al. (1997) for the period 1970 – 1988. The catch at age data was corrected to the official landings (SOP corrections). They do represent officially reported landings and do not include any discards and unreported catches.

Assessment and qualitative assumptions about the IUU (Illegal, Unregulated and Unreported) fishing of turbot were made and rates of the Potential Unreported Catch in 2002-2010 were estimated as a proportion between Turkish catch in 1993-2001 and 2009-2010, which then was added to the officially reported catch.

The mean weights at ages in the stock for the period 1989-2010 were assumed equal to the catch weights at age in the landings due to lack of data. Theoretical weights (Ivanov, Karapetkova, 1979) were used to estimate stock biomass in 1970 – 1988.

An average natural mortality (M) of 0.19 is applied in all ages and years.

The XSA was tuned with different combinations of the 4 series of CPUE from Bulgarian, Romanian, Ukrainean and Turkish fleet, ages 2-10+ over the period 1987-2010. After different runs, STECF EWG 11 16 decided to excude age 2 from tunning series. The sensitivity of SSB, recruitment and F to inclusion/exclusion of different tuning fleets are presented on Fig.1.2.6.2.1.

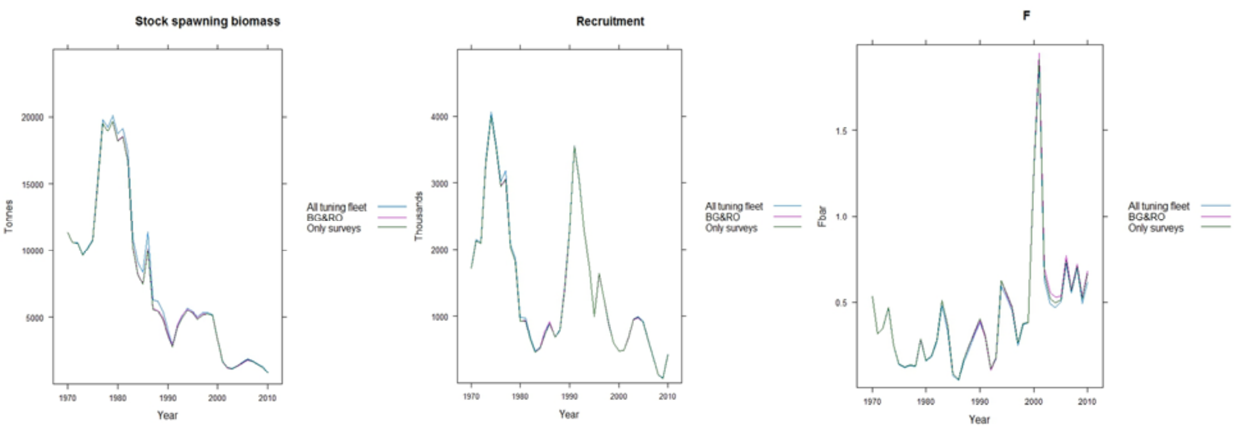


Fig.6.2.4.1.2.1. Sensitivity analysis of tuning series over the SSB, recruitment and F.

STECF EWG 11 16 considered to omit commercial fleet tuning series due to alterations in fleet effectivness over the period 1987 - 2010 and to use only survey data. The observed impact of different combinations of tuning series is not significant over SSB, recruitment and F and the STECF EWG 11 16 decided to exclude the Ukrainean series due to lack of data for 5 years within the period 1970 - 2007. Final analysis includes only Romanian and Bulgarian tuning series.

STECF EWG 11 16 accomplished analysis of residuals of tuning series (Bulgarian and Romanian fleet). The residuals from Romanian data are lower - Fig.6.2.4.1.2.2.

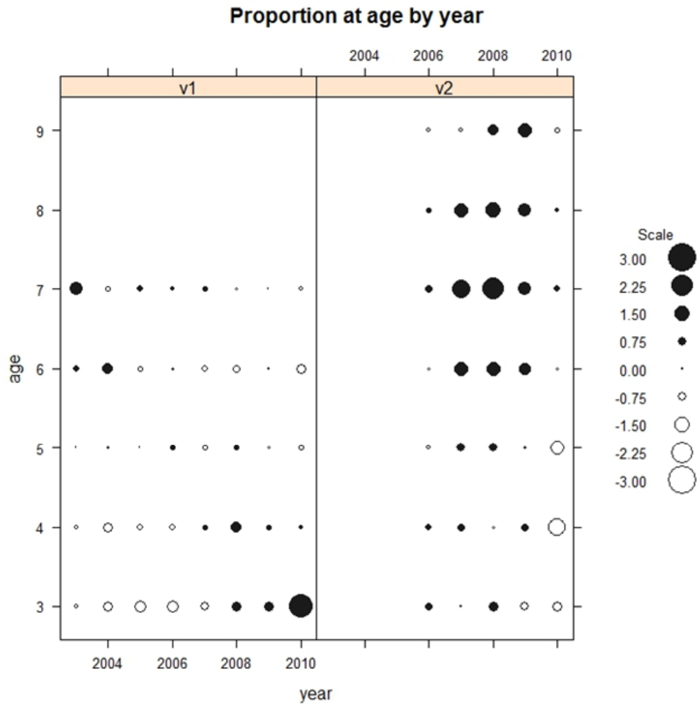


Fig. 6.2.4.1.2.2. Residuals of tuning series: v1 - Romania, v2 - Bulgaria.

The input data for XSA includes two versions - compiled according to the official landings statistics (Table 6.2.4.1.2.1) and landings with estimated IUU catches (Table 6.2.4.1.2.2)

Table 6.2.4.1.2.1. Turbot in the Black Sea 1970-2010. XSA input parameters, official landings.

Year	Landings (t)	Year	Landings (t)
1970	5273	1992	439
1971	3052	1993	1603
1972	3049	1994	2144
1973	3705	1995	2943
1974	1696	1996	2048
1975	1273	1997	1025
1976	1584	1998	1588
1977	2012	1999	1953
1978	2160	2000	2789
1979	5447	2001	2557
1980	2843	2002	618
1981	3276	2003	424
1982	4662	2004	434
1983	5307	2005	741
1984	2852	2006	967
1985	527	2007	1035
1986	428	2008	816
1987	849	2009	731
1988	1116	2010	621
1989	1460	2009	731
1990	1393	2010	622
1991	935		

Catch-at-age (nbs, 10^3)

Year/Age	1	2	3	4	5	6	7	8	9	10+
1970	0.010	94.921	462.441	224.711	706.313	406.052	306.826	109.558	49.936	54.347
1971	0.010	3.256	86.051	779.262	360.454	338.448	256.63	75.647	30.331	27.908
1972	0.010	2.815	109.343	74.783	303.94	314.25	263.336	108.762	42.401	48.066
1973	0.010	4.926	68.381	90.04	401.258	344.068	302.546	112.531	49.626	71.775
1974	0.010	3.342	8.92	14.118	71.015	164.262	162.345	57.732	35.46	63.915
1975	0.010	0.286	15.219	41.674	198.185	135.558	86.844	26.51	9.851	13.559
1976	0.010	38.796	121.633	49.187	145.583	130.54	90.853	26.821	17.814	48.295
1977	0.010	28.938	68.088	32.032	104.841	133.082	126.737	42.091	35.205	91.843
1978	0.010	31.278	89.925	70.004	273.314	187.205	138.891	42.635	26.81	44.777
1979	0.010	5.135	212.865	152.254	583.676	476.63	362.663	111.958	74.229	154.821
1980	0.010	18.629	110.325	60	236.01	281.131	214.6	71.735	37.017	75.607
1981	0.010	27.783	115.374	36.996	116.115	208.813	255.314	139.355	78.232	127.803
1982	0.010	0.1	180.744	108.3	314.743	267.14	268.608	119.803	110.38	245.357
1983	0.010	0.1	234.916	146.595	558.273	315.725	285.921	115.338	105.161	223.284
1984	0.010	0.1	87.748	80.728	74.586	122.847	131.622	107.93	74.586	197.433
1985	0.010	0.1	1.4	4.061	7.841	15.262	27.444	13.022	21.983	49.006
1986	0.010	0.1	0.1	0.4	8.819	10.322	21.044	0.401	4.61	55.017
1987	0.010	0.1	2.024	14.165	21.501	81.449	23.777	23.271	14.671	72.089
1988	0.010	0.1	0.1	0.4	34.493	52.206	43.195	67.433	15.227	98.195
1989	3.690	11.740	32.871	40.921	59.034	67.755	34.548	16.771	15.765	52.326
1990	20.240	56.477	68.957	105.919	95.652	37.452	29.574	20.968	13.084	36.027
1991	50.695	65.044	111.160	80.626	55.577	43.289	33.490	7.741	5.626	5.626
1992	21.979	52.976	36.172	36.776	21.370	16.726	18.868	12.291	2.819	3.045
1993	244.303	529.756	444.536	182.992	77.134	31.439	17.854	17.841	13.911	3.943
1994	0.751	134.215	310.266	245.465	223.977	68.808	48.811	43.179	36.796	11.280
1995	18.946	67.477	47.242	312.768	488.344	247.768	87.393	18.823	2.455	2.455
1996	70.261	35.131	37.227	119.117	154.502	192.271	88.846	38.864	9.148	0.010
1997	0.010	0.010	61.642	48.228	43.118	49.825	68.030	31.939	13.414	3.194
1998	0.010	0.010	8.872	25.562	72.902	174.631	96.235	54.292	11.101	0.010
1999	0.010	0.010	69.125	113.114	75.410	182.240	144.535	25.137	12.568	6.284
2000	3.680	109.187	97.545	131.344	106.807	77.977	195.864	109.884	56.477	17.191
2001	0.010	28.092	42.012	131.444	244.364	319.142	102.619	21.882	2.554	7.661
2002	0.010	30.403	58.957	44.650	52.585	36.658	26.046	2.154	0.468	0.562
2003	1.340	8.515	14.844	13.837	23.158	32.754	35.114	5.872	0.330	0.198
2004	3.772	9.881	19.766	21.196	25.240	30.482	20.914	11.222	1.285	0.010
2005	1.559	26.966	80.917	82.865	57.747	27.747	22.893	15.170	1.320	0.425
2006	11.250	52.329	69.633	93.432	68.208	41.631	35.661	6.870	8.913	0.010
2007	13.958	55.447	103.969	197.367	95.019	48.622	17.649	2.302	2.243	0.240
2008	5.139	54.603	56.756	124.938	78.050	52.221	27.147	9.558	1.588	0.607
2009	0.010	28.501	76.144	85.405	55.309	31.942	39.838	6.533	0.938	0.010
2010	5.909	2.998	9.613	33.412	59.136	49.498	27.791	12.961	4.343	1.069

Weight-at-age in catch (kg)

	1	2	3	4	5	6	7	8	9	10 +
1970	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1971	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1972	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1973	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1974	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1975	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1976	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1977	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1978	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1979	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1980	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1981	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1982	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1983	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1984	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1985	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1986	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1987	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1988	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1989	0.500	1.000	1.400	1.800	2.200	3.300	4.000	5.300	6.600	12.117
1990	0.457	0.730	1.247	1.777	2.160	3.243	3.900	5.447	6.500	12.278
1991	0.383	0.777	1.153	1.710	2.120	3.030	4.257	5.467	6.600	12.352
1992	0.727	0.947	1.427	1.997	2.647	3.907	5.283	6.300	8.800	9.537
1993	0.453	0.893	1.100	1.543	2.087	2.963	4.443	5.820	8.340	9.369
1994	0.600	0.760	1.070	1.593	2.083	2.597	4.200	5.900	8.300	9.473
1995	0.090	0.720	0.953	1.570	2.220	2.993	4.423	6.000	8.500	9.500
1996	0.417	0.822	1.000	1.600	2.100	2.800	4.300	6.000	9.500	10.314
1997	0.417	0.822	1.000	1.600	2.100	2.800	4.300	6.000	9.500	10.500
1998	0.417	0.822	1.300	1.700	2.200	3.100	4.300	6.000	7.000	10.314
1999	0.417	0.822	1.300	1.700	2.200	3.100	4.300	6.000	7.000	9.500
2000	0.180	0.430	1.227	1.567	2.223	2.870	3.913	5.233	6.620	8.321
2001	0.417	0.822	1.300	1.700	2.300	3.100	4.100	5.700	9.500	12.667
2002	0.417	0.852	1.283	1.938	2.532	3.197	4.117	5.400	6.600	10.250
2003	0.477	0.793	1.292	1.975	2.400	3.116	4.078	5.400	6.600	10.000
2004	0.486	0.973	1.429	1.953	2.517	3.183	4.238	5.796	6.800	10.314
2005	0.160	0.843	1.321	1.938	2.545	3.436	4.388	5.780	7.500	9.842
2006	0.621	0.999	1.507	2.114	2.680	3.501	4.467	5.828	7.400	10.314
2007	0.291	0.794	1.400	1.891	2.441	3.119	4.706	6.060	7.500	9.000
2008	0.380	0.828	1.456	1.901	2.466	2.969	3.863	4.473	5.697	6.643
2009	0.365	0.660	1.155	1.749	2.423	3.415	4.197	5.192	6.323	7.109
2010	0.350	0.683	1.188	1.726	2.511	2.622	3.846	5.177	5.999	7.575

Weight-at-age in the stock (kg)

	1	2	3	4	5	6	7	8	9	10 +
1970	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1971	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1972	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1973	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1974	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1975	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1976	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1977	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1978	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1979	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1980	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1981	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1982	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1983	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1984	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1985	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1986	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1987	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1988	0.614	1.083	1.646	2.292	3.004	3.731	4.456	5.17	5.876	7.458
1989	0.500	1.000	1.400	1.800	2.200	3.300	4.000	5.300	6.600	12.117
1990	0.457	0.730	1.247	1.777	2.160	3.243	3.900	5.447	6.500	12.278
1991	0.383	0.777	1.153	1.710	2.120	3.030	4.257	5.467	6.600	12.352
1992	0.727	0.947	1.427	1.997	2.647	3.907	5.283	6.300	8.800	9.537
1993	0.453	0.893	1.100	1.543	2.087	2.963	4.443	5.820	8.340	9.369
1994	0.600	0.760	1.070	1.593	2.083	2.597	4.200	5.900	8.300	9.473
1995	0.090	0.720	0.953	1.570	2.220	2.993	4.423	6.000	8.500	9.500
1996	0.614	1.083	1.000	1.600	2.100	2.800	4.300	6.000	9.500	7.458
1997	0.614	1.083	1.000	1.600	2.100	2.800	4.300	6.000	9.500	10.500
1998	0.614	1.083	1.300	1.700	2.200	3.100	4.300	6.000	7.000	10.314
1999	0.614	1.083	1.300	1.700	2.200	3.100	4.300	6.000	7.000	9.500
2000	0.180	1.083	1.227	1.567	2.223	2.870	3.913	5.233	6.620	8.321
2001	0.614	1.083	1.300	1.700	2.300	3.100	4.100	5.700	9.500	12.667
2002	0.614	0.852	1.283	1.938	2.532	3.197	4.117	5.400	6.600	10.250
2003	0.614	0.793	1.292	1.975	2.400	3.116	4.078	5.400	6.600	10.000
2004	0.486	0.973	1.429	1.953	2.517	3.183	4.238	5.796	6.800	7.458
2005	0.160	0.843	1.321	1.938	2.545	3.436	4.388	5.780	7.500	9.842
2006	0.621	0.999	1.507	2.114	2.680	3.501	4.467	5.828	7.400	7.458
2007	0.291	0.794	1.400	1.891	2.441	3.119	4.706	6.060	7.500	9.000
2008	0.380	0.828	1.456	1.901	2.466	2.969	3.863	4.473	5.697	6.643
2009	0.365	0.660	1.155	1.749	2.423	3.415	4.197	5.192	6.323	7.109
2010	0.350	0.683	1.188	1.726	2.511	2.622	3.846	5.177	5.999	7.575

Maturity ogive

	1	2	3	4	5	6	7	8	9	10+
1970	0	0	0.75	1	1	1	1	1	1	1
1971	0	0	0.75	1	1	1	1	1	1	1
1972	0	0	0.75	1	1	1	1	1	1	1
1973	0	0	0.75	1	1	1	1	1	1	1
1974	0	0	0.75	1	1	1	1	1	1	1
1975	0	0	0.75	1	1	1	1	1	1	1
1976	0	0	0.75	1	1	1	1	1	1	1
1977	0	0	0.75	1	1	1	1	1	1	1
1978	0	0	0.75	1	1	1	1	1	1	1
1979	0	0	0.75	1	1	1	1	1	1	1
1980	0	0	0.75	1	1	1	1	1	1	1
1981	0	0	0.75	1	1	1	1	1	1	1
1982	0	0	0.75	1	1	1	1	1	1	1
1983	0	0	0.75	1	1	1	1	1	1	1
1984	0	0	0.75	1	1	1	1	1	1	1
1985	0	0	0.75	1	1	1	1	1	1	1
1986	0	0	0.75	1	1	1	1	1	1	1
1987	0	0	0.75	1	1	1	1	1	1	1
1988	0	0	0.75	1	1	1	1	1	1	1
1989	0	0	0.75	1	1	1	1	1	1	1
1990	0	0	0.75	1	1	1	1	1	1	1
1991	0	0	0.75	1	1	1	1	1	1	1
1992	0	0	0.75	1	1	1	1	1	1	1
1993	0	0	0.75	1	1	1	1	1	1	1
1994	0	0	0.75	1	1	1	1	1	1	1
1995	0	0	0.75	1	1	1	1	1	1	1
1996	0	0	0.75	1	1	1	1	1	1	1
1997	0	0	0.75	1	1	1	1	1	1	1
1998	0	0	0.75	1	1	1	1	1	1	1
1999	0	0	0.75	1	1	1	1	1	1	1
2000	0	0	0.75	1	1	1	1	1	1	1
2001	0	0	0.75	1	1	1	1	1	1	1
2002	0	0	0.75	1	1	1	1	1	1	1
2003	0	0	0.75	1	1	1	1	1	1	1
2004	0	0	0.75	1	1	1	1	1	1	1
2005	0	0	0.75	1	1	1	1	1	1	1
2006	0	0	0.75	1	1	1	1	1	1	1
2007	0	0	0.38	0.61	1	1	1	1	1	1
2008	0	0	0.51	0.76	1	1	1	1	1	1
2009	0	0	0.41	0.67	1	1	1	1	1	1
2010	0	0	0.22	0.83	1	1	1	1	1	1

Tuning series

Romania						
	2	3	4	5	6	7
2003	42.128	79.962	75.329	87.249	112.536	75.571
2004	44.134	75.775	60.611	103.477	108.773	30.690
2005	25.087	81.031	113.648	99.979	37.855	30.366
2006	18.894	78.997	146.391	177.682	54.103	18.398
2007	19.205	100.181	242.311	131.348	41.724	26.786
2008	212.502	234.076	360.282	159.646	56.092	22.652
2009	16.915	101.588	142.214	111.757	60.963	37.252
2010	11.887	14.420	48.521	52.808	31.373	20.071

Bulgaria									
	2	3	4	5	6	7	8	9	10+
2006	53.225	222.363	259.030	108.816	41.397	24.838	10.645	7.097	2.366
2007	8.275	124.125	233.079	328.241	204.116	86.887	13.792	2.758	0.000
2008	4.957	171.014	118.966	215.626	270.153	161.100	19.828	4.957	2.478
2009	0.000	19.952	139.662	136.593	155.010	102.828	30.695	6.139	1.535
2010	11.484	5.104	7.656	24.244	57.419	37.004	17.864	3.828	1.276

Ukraine									
	2	3	4	5	6	7	8	9	10+
1989	7.107	19.901	24.774	35.740	41.019	20.916	10.153	9.544	8.935
1990	2.862	5.128	13.117	13.833	18.126	19.676	11.686	8.705	5.843
1991	15.301	24.842	41.044	29.703	28.803	21.602	4.680	4.140	0.900
1992	36.745	48.051	37.772	33.147	38.029	28.008	6.424	5.396	1.028
1993	14.045	27.579	29.367	53.371	34.729	33.197	29.367	25.026	5.618
1994	13.487	26.484	28.201	51.252	33.350	31.879	28.201	24.032	5.395
1995									
1996									
1997									
1998		6.453	19.359	55.497	122.932	70.339	37.105	10.970	
1999									
2000									
2001	10.230	31.560	60.944	77.703	22.854	4.571	0.653	0.653	0.653
2002		27.166	50.198	89.765	64.962	53.151	6.791	1.476	0.886
2003	5.976	11.578	23.530	60.505	95.986	139.684	33.240	1.867	1.120
2004	3.219	18.509	45.968	60.233	89.022	104.555	40.844	12.845	
2005	6.397	9.500	20.993	45.174	49.180	95.172	70.173	13.611	3.230
2006	1.389	30.567	176.456	114.858	71.323	50.482	7.873	10.189	
2007	3.445	33.159	153.739	121.441	56.845	39.619	9.043	12.058	1.292

Turkey										
	1	2	3	4	5	6	7	8	9	10+
1987	0.092	0.916	18.532	129.699	196.870	745.774	217.710	213.077	134.332	660.070
1988	0.113	1.134	1.134	4.535	391.071	591.896	489.732	764.535	172.639	1113.305
1989	43.444	138.231	387.046	481.833	695.104	797.790	406.794	197.473	185.624	616.115
1990	122.742	342.494	418.174	642.325	580.063	227.123	179.347	127.157	79.348	218.478
1991	506.200	649.473	1109.943	805.063	554.942	432.242	334.404	77.299	56.179	56.179
1992	92.574	223.130	152.354	154.896	90.009	70.447	79.471	51.770	11.874	12.824
1993	298.977	648.313	544.021	223.945	94.396	38.474	21.850	21.833	17.024	4.826
1994	5.161	922.426	2132.378	1687.020	1539.339	472.902	335.466	296.758	252.890	77.528
1995	145.101	516.782	361.808	2395.367	3740.039	1897.558	669.310	144.157	18.803	18.803
1996	156.050	78.025	82.681	264.558	343.149	427.034	197.326	86.317	20.318	0.022
1997	0.023	0.023	139.883	109.442	97.846	113.066	154.379	72.478	30.441	7.248
1998	0.034	0.034	30.408	87.610	249.865	598.528	329.836	186.081	38.047	0.034
1999	0.019	0.019	133.808	218.958	145.972	352.766	279.780	48.657	24.329	12.164
2000	12.917	383.211	342.350	460.973	374.857	273.674	687.416	385.656	198.216	60.334
2001	0.014	38.598	57.724	180.602	335.751	438.496	140.997	30.065	3.509	10.527
2002	0.016	50.259	97.461	73.810	86.928	60.599	43.056	3.561	0.774	0.929
2003	7.082	45.008	78.459	73.136	122.406	173.125	185.598	31.039	1.744	1.046
2004	17.923	46.951	93.920	100.717	119.933	144.840	99.376	53.325	6.105	0.045
2005	5.503	95.163	285.551	292.425	203.785	97.917	80.789	53.536	4.658	1.500
2006	42.012	195.419	260.042	348.915	254.720	155.467	133.174	25.655	33.284	0.037
2007	44.048	174.978	328.102	622.842	299.856	153.438	55.696	7.264	7.077	0.758
2008	12.220	128.948	116.154	262.842	129.341	93.573	17.529	5.551	0.802	0.028
2009	0.023	81.900	206.137	217.242	106.886	47.890	34.009	0.023	0.023	0.023
2010	44.124	22.397	35.193	100.003	232.336	137.615	95.218	68.691	4.745	0.010

F on the latest age – 0.15 for all years

F in the last year

	1	2	3	4	5	6	7	8	9	10+
F	0.01	0.01	0.1	0.8	0.25	0.3	0.4	0.25	0.2	0.15

Table 6.2.4.1.2.2. Turbot in the Black Sea 1970-2010. XSA input parameters, official landings with IUU catches estimated.

Year	Landings (t)	Year	Landings (t)
1970	5273	1992	439
1971	3052	1993	1603
1972	3049	1994	2144
1973	3705	1995	2943
1974	1696	1996	2048
1975	1273	1997	1025
1976	1584	1998	1588
1977	2012	1999	1953
1978	2160	2000	2789
1979	5447	2001	2557
1980	2843	2002	1412
1981	3276	2003	943
1982	4662	2004	989
1983	5307	2005	2039
1984	2852	2006	2737
1985	527	2007	2692
1986	428	2008	1901
1987	849	2009	1541
1988	1116	2010	1321
1989	1460	2009	1412
1990	1393	2010	943
1991	935		

Catch-at-age (nbs, 10^3)

Year/Age	1	2	3	4	5	6	7	8	9	10+
1970	0.010	94.921	462.441	224.711	706.313	406.052	306.826	109.558	49.936	54.347
1971	0.010	3.256	86.051	779.262	360.454	338.448	256.63	75.647	30.331	27.908
1972	0.010	2.815	109.343	74.783	303.94	314.25	263.336	108.762	42.401	48.066
1973	0.010	4.926	68.381	90.04	401.258	344.068	302.546	112.531	49.626	71.775
1974	0.010	3.342	8.92	14.118	71.015	164.262	162.345	57.732	35.46	63.915
1975	0.010	0.286	15.219	41.674	198.185	135.558	86.844	26.51	9.851	13.559
1976	0.010	38.796	121.633	49.187	145.583	130.54	90.853	26.821	17.814	48.295
1977	0.010	28.938	68.088	32.032	104.841	133.082	126.737	42.091	35.205	91.843
1978	0.010	31.278	89.925	70.004	273.314	187.205	138.891	42.635	26.81	44.777
1979	0.010	5.135	212.865	152.254	583.676	476.63	362.663	111.958	74.229	154.821
1980	0.010	18.629	110.325	60	236.01	281.131	214.6	71.735	37.017	75.607
1981	0.010	27.783	115.374	36.996	116.115	208.813	255.314	139.355	78.232	127.803
1982	0.010	0.1	180.744	108.3	314.743	267.14	268.608	119.803	110.38	245.357
1983	0.010	0.1	234.916	146.595	558.273	315.725	285.921	115.338	105.161	223.284
1984	0.010	0.1	87.748	80.728	74.586	122.847	131.622	107.93	74.586	197.433
1985	0.010	0.1	1.4	4.061	7.841	15.262	27.444	13.022	21.983	49.006
1986	0.010	0.1	0.1	0.4	8.819	10.322	21.044	0.401	4.61	55.017
1987	0.010	0.1	2.024	14.165	21.501	81.449	23.777	23.271	14.671	72.089
1988	0.010	0.1	0.1	0.4	34.493	52.206	43.195	67.433	15.227	98.195
1989	3.690	11.740	32.871	40.921	59.034	67.755	34.548	16.771	15.765	52.326
1990	20.240	56.477	68.957	105.919	95.652	37.452	29.574	20.968	13.084	36.027
1991	50.695	65.044	111.160	80.626	55.577	43.289	33.490	7.741	5.626	5.626
1992	21.979	52.976	36.172	36.776	21.370	16.726	18.868	12.291	2.819	3.045
1993	244.303	529.756	444.536	182.992	77.134	31.439	17.854	17.841	13.911	3.943
1994	0.751	134.215	310.266	245.465	223.977	68.808	48.811	43.179	36.796	11.280
1995	18.946	67.477	47.242	312.768	488.344	247.768	87.393	18.823	2.455	2.455
1996	70.261	35.131	37.227	119.117	154.502	192.271	88.846	38.864	9.148	0.010
1997	0.010	0.010	61.642	48.228	43.118	49.825	68.030	31.939	13.414	3.194
1998	0.010	0.010	8.872	25.562	72.902	174.631	96.235	54.292	11.101	0.010
1999	0.010	0.010	69.125	113.114	75.410	182.240	144.535	25.137	12.568	6.284
2000	3.680	109.187	97.545	131.344	106.807	77.977	195.864	109.884	56.477	17.191
2001	0.010	28.092	42.012	131.444	244.364	319.142	102.619	21.882	2.554	7.661
2002	0.010	79.961	148.930	110.457	128.754	89.635	63.578	5.250	1.141	1.369
2003	2.537	20.471	33.582	28.226	53.471	76.362	86.349	15.796	0.887	0.532
2004	1.821	13.265	36.709	46.228	60.885	73.196	58.005	26.890	5.183	0.010
2005	1.559	49.463	96.474	140.665	108.857	80.221	108.083	74.992	11.970	3.855
2006	15.658	75.550	139.291	314.086	228.944	129.574	95.583	15.879	20.130	0.000
2007	15.453	88.621	204.394	461.007	271.085	123.520	58.256	11.151	13.378	1.433
2008	4.864	69.507	99.938	221.254	179.560	113.044	93.380	32.830	5.583	2.465
2009	0.010	37.942	113.510	140.696	123.510	84.591	130.151	26.686	3.833	0.010
2010	13.950	7.077	22.693	78.873	139.599	116.846	65.605	30.597	10.253	2.524

7.2.4.1.3 Results

The STECF EWG 11 16 Black Sea applied the Extended Survivors Analysis (XSA) under FLR and the technique “shrinkage to the mean” for assessing the stock of turbot in 1970-2010.

The tuning of XSA is defined according to the default settings of the program. Catchability is set dependent on stock size for ages <3 and independent of age for ages >=5. The tuning diagnostics indicates standard errors of the log transformed catchabilities and regression parameters (slopes and r-squared) at acceptable levels. (Tab. 6.2.4.1.3.1).

Fig. 6.2.4.1.3.1 illustrates the retrospective behaviour of the fishing mortality (average over ages 4-8), SSB and recruitment. The retrospective runs consistently underestimate recruitment and SSB and show no systematic effect on fishing mortality.

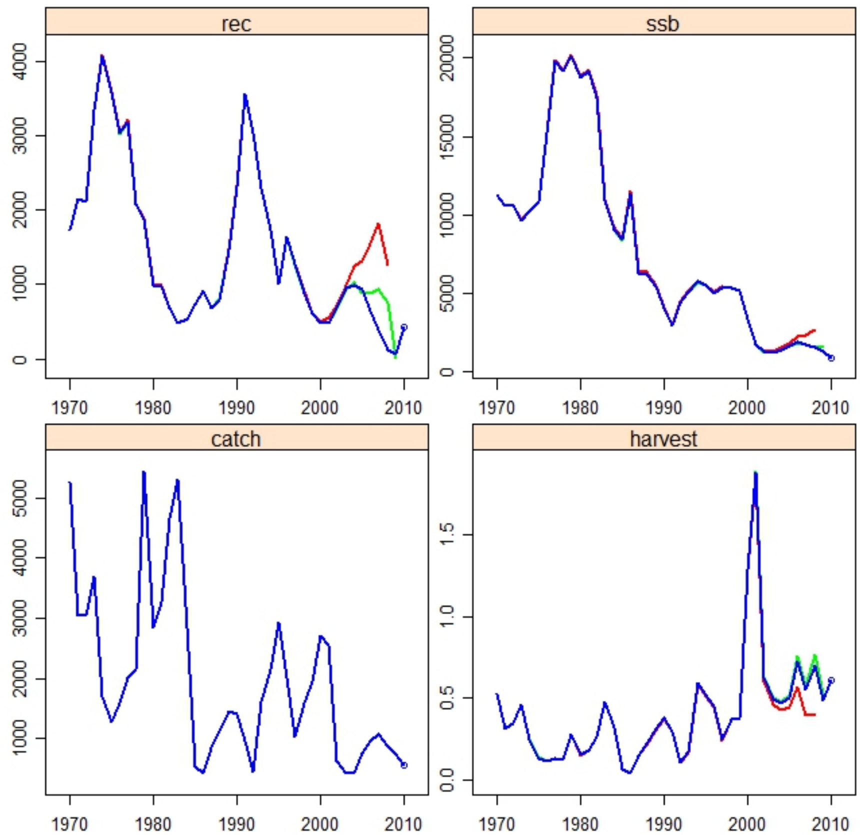


Fig. 6.2.4.1.3.1. Turbot in the Black Sea. Retrospective trends of the assessment parameters fishing mortality (average over ages 4-8), SSB and recruitment.

XSA outputs and diagnostics are listed in the Tab. 1.1.6.3.1.

Tab. 6.2.4.1.3.1. Turbot in the Black Sea. XSA results and diagnostics.

```
FLR      XSA      Diagnostics        12.10.2011         14:11:33 CPUE      data      from      bst.idx[c(1 3)]

Catch    data for 41 years   1970 to 2010 Ages 1 to 10

         fleet    first    age      last     age      first    year     last     year     alpha    beta
1        RO       Trawl    fleet    3        7        2003     2010     <NA>     <NA>
2        BG       Trawl    survey   3        9        2006     2010     <NA>     <NA>

         Time     series   weights  :
         Tapered  time     weighting not     applied
          Catchability     analysis :
          Catchability     independent       of       size     for      ages     >        2
         Catchability      independent       of       age      for      ages     >        5                            Terminal
         population        estimation        :
          Survivor estimates shrunk   towards  the      mean     F of the final 5 years or the5 oldest  ages.
         S.E. of  the mean to which the estimates are shrunk     =
         Minimum standard error for population estimates derived from each fleet = 0.3
         prior weighting   not applied
```

Regression *weights* year

age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
all	1	1	1	1	1	1	1	1	1	1

Fishing *mortalities* year

age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0	0	0.002	0.002	0.002	0.019	0.042	0.043	0	0.016
2	0.084	0.095	0.018	0.01	0.038	0.079	0.126	0.21	0.435	0.064
3	0.166	0.274	0.06	0.047	0.153	0.126	0.224	0.176	0.565	0.242
4	0.449	0.287	0.093	0.114	0.299	0.258	0.629	0.448	0.46	0.493
5	1.056	0.351	0.232	0.254	0.462	0.425	0.45	0.545	0.376	0.64
6	2.021	0.457	0.377	0.508	0.424	0.714	0.605	0.478	0.457	0.649
7	3.279	1.195	1.099	0.411	0.893	1.712	0.743	0.84	0.86	0.888
8	2.951	1.203	0.977	1.358	0.581	0.728	0.431	1.298	0.489	0.731
9	1.977	0.705	0.56	0.533	0.514	0.805	0.548	0.597	0.394	0.675
10	1.977	0.705	0.56	0.533	0.514	0.805	0.548	0.597	0.394	0.675

XSA population number *(Thousand)*

age year	1	2	3	4	5	6	7	8	9	10
2001	490	389	306	404	417	409	119	26	3	10
2002	678	405	296	215	213	120	45	4	1	1
2003	948	560	305	186	133	124	63	11	1	1
2004	979	783	455	237	140	87	70	17	3	0
2005	912	808	641	359	175	90	43	39	4	1
2006	642	753	643	455	220	91	49	15	18	0
2007	378	521	575	469	291	119	37	7	6	1
2008	116	300	380	380	207	153	54	15	4	1
2009	64	92	201	263	201	99	79	19	3	0
2010	418	53	49	94	138	114	52	27	10	2

Estimated population abundance at 1st Jan 2011 age

year	1	2	3	4	5	6	7	8	9	10
	2011	0	340	41	32	48	60	49	18	11	4

Fleet: *RO* *Trawl* *fleet*

Log catchability residuals.

year age	2003	2004	2005	2006	2007	2008	2009	2010
3	-0.239	-0.701	-0.921	-0.964	-0.564	0.675	0.676	2.038
4	-0.217	-0.667	-0.357	-0.362	0.301	0.816	0.259	0.227
5	-0.008	0.122	-0.028	0.299	-0.268	0.316	-0.098	-0.335
6	0.39	0.775	-0.353	0.137	-0.444	-0.464	0.044	-0.664
7	1.036	-0.325	0.39	0.176	0.353	-0.142	-0.013	-0.204

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	3	4	5	6	7
Mean_Logq	-0.9684	-0.5395	-0.1954	-0.1954	-0.1954
S.E_Logq	1.0494	0.4817	0.2386	0.4942	0.4386

Fleet: *BG* *Trawl* *survey*

Log catchability residuals.

year age	2006	2007	2008	2009	2010
3	0.459	0.038	0.749	-0.563	-0.684
4	0.449	0.502	-0.052	0.481	-1.379
5	-0.204	0.635	0.604	0.09	-1.126
6	-0.143	1.131	1.095	0.964	-0.072
7	0.463	1.517	1.807	0.989	0.396
8	0.33	1.145	1.247	1.003	0.225
9	-0.231	-0.193	0.828	1.112	-0.306

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	3	4	5	6	7	8	9
Mean_Logq	-1.3567	-0.7795	-0.1828	-0.1828	-0.1828	-0.1828	-0.1828
S.E_Logq	0.624	0.8047	0.7221	0.6449	0.6257	0.4774	0.673

Terminal year survivor and F summaries:

Age 1 Year class 2009

source	scaledWts	survivors	yrcls
fshk	0.759	250	2009
nshk	0.241	905	2009

Age 2 Year class 2008

source	scaledWts	survivors	yrcls
fshk	1	14	2008

Age 3 Year class 2007

source	scaledWts	survivors	yrcls		
RO	Trawl	fleet	0.1	245	2007
BG	Trawl	survey	0.266	16	2007
fshk	0.634	31	2007		

Age 4 Year class 2006

source	scaledWts	survivors	yrcls

```
RO        Trawl     fleet     0.328     60        2006
BG        Trawl     survey    0.11      12        2006
fshk      0.561     58        2006

          Age       5         Year      class     2005

source
          scaledWts survivors yrcls
RO        Trawl     fleet     0.547     43        2005
BG        Trawl     survey    0.079     19        2005
fshk      0.374     93        2005

          Age       6         Year      class     2004

source
          scaledWts survivors yrcls
RO        Trawl     fleet     0.292     25        2004
BG        Trawl     survey    0.08      46        2004
fshk      0.628     63        2004

          Age       7         Year      class     2003

source
          scaledWts survivors yrcls
RO        Trawl     fleet     0.282     14        2003
BG        Trawl     survey    0.034     26        2003
fshk      0.684     14        2003

          Age       8         Year      class     2002

source
          scaledWts survivors yrcls
BG        Trawl     survey    0.091     14        2002
fshk      0.909     11        2002

          Age       9         Year      class     2001

source
          scaledWts survivors yrcls
BG        Trawl     survey    0.168     3         2001
fshk      0.832     4         2001
```

Summary of results

```
An object of class "FLStock"
Slot "catch": An object of class "FLQuant", unit = unique, season = all, area = unique

     year
age   1970    1971    1972    1973    1974    1975    1976    1977    1978
  all 5273.39 3051.59 3049.39 3704.59 1696.39 1272.89 1583.49 2011.68 2159.70
     year
age   1979    1980    1981    1982    1983    1984    1985    1986    1987
  all 5447.18 2842.78 3275.48 4662.36 5306.47 2851.76  526.90  428.39  849.39
     year
age   1988    1989    1990    1991    1992    1993    1994    1995    1996
  all 1115.58 1459.89 1410.69  952.19  438.29 1602.75 2143.88 2942.86 2023.10
     year
age   1997    1998    1999    2000    2001    2002    2003    2004    2005
  all 1025.01 1588.12 1953.01 2716.48 2549.28  618.18  423.40  420.92  749.49
     year
age   2006    2007    2008    2009    2010
  all  964.55 1075.15  878.67  730.65  559.61

units:  NA NA

Slot "catch.n":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

    year
age       1970    1971    1972    1973    1974    1975    1976    1977    1978
  1    0.007   0.005   0.006   0.007   0.007   0.007   0.007   0.007   0.007
  2   65.448   1.603   1.795   3.276   2.194   0.191  26.854  21.541  21.158
  3  318.853  42.369  69.707  45.478   5.856  10.169  84.191  50.683  60.831
  4  154.938 383.684  47.675  59.883   9.269  27.845  34.046  23.844  47.355
  5  487.003 177.476 193.765 266.866  46.625 132.422 100.769  78.042 184.886
  6  279.973 166.641 200.337 228.830 107.847  90.576  90.356  99.064 126.636
  7  211.556 126.356 167.879 201.215 106.588  58.027  62.886  94.341  93.954
  8   75.540  37.246  69.337  74.841  37.904  17.713  18.565  31.332  28.841
  9   34.431  14.934  27.031  33.005  23.281   6.582  12.330  26.206  18.136
  10  37.472  13.741  30.643  47.736  41.964   9.060  33.429  68.366  30.290   year
year
age     1979    1980    1981    1982    1983    1984    1985    1986    1987
  1    0.007   0.007   0.007   0.007   0.007   0.007   0.007   0.007   0.007
  2    3.487  12.592  19.347   0.069   0.069   0.070   0.068   0.071   0.068
  3  144.537  74.573  80.342 124.240 161.236  61.526   0.950   0.071   1.370
  4  103.382  40.556  25.763  74.443 100.617  56.603   2.756   0.286   9.591
  5  396.321 159.528  80.858 216.348 383.175  52.297   5.321   6.302  14.558
  6  323.636 190.027 145.410 183.627 216.700  86.136  10.356   7.377  55.147
  7  246.251 145.056 177.792 184.636 196.244  92.288  18.622  15.039  16.099
  8   76.020  48.488  97.042  82.350  79.163  75.676   8.836   0.287  15.756
  9   50.402  25.021  54.478  75.873  72.178  52.297  14.917   3.294   9.933
  10 105.125  51.106  88.998 168.654 153.253 138.432  33.253  39.317  48.810
    year
age       1988    1989    1990    1991    1992    1993    1994    1995    1996
  1    0.007   3.710  20.254  55.073  17.705 201.279   0.687  18.864  76.792
  2    0.067  11.804  56.517  70.661  42.675 436.461 122.823  67.184  38.396
  3    0.067  33.052  69.006 120.758  29.139 366.249 283.930  47.037  40.687
  4    0.268  41.147 105.994  87.588  29.625 150.765 224.630 311.408 130.189
  5   23.146  59.359  95.720  60.376  17.215  63.550 204.966 486.222 168.863
  6   35.031  68.128  37.479  47.027  13.473  25.902  62.968 246.691 210.143
  7   28.985  34.739  29.595  36.382  15.199  14.710  44.668  87.013  97.104
  8   45.249  16.863  20.983   8.410   9.901  14.699  39.514  18.741  42.477
  9   10.218  15.852  13.094   6.112   2.271  11.461  33.673   2.444   9.999
  10  65.891  52.614  36.052   6.112   2.453   3.249  10.323   2.444   0.011
    year
```

```
age       1997    1998    1999    2000    2001    2002    2003    2004    2005
  1    0.010   0.010   0.010   3.713   0.010   0.010   1.452   1.361   1.590
  2    0.010   0.010   0.010 110.151  28.426  33.198   9.230   7.401  27.498
  3   62.311   8.951  69.841  98.406  42.512  64.377  16.090  18.841  82.513
  4   48.751  25.789 114.285 132.503 133.008  48.754  14.999  23.199  84.500
  5   43.585  73.551  76.190 107.750 247.270  57.419  25.103  28.551  58.886
  6   50.365 176.184 184.125  78.666 322.937  40.028  35.504  31.623  28.294
  7   68.768  97.091 146.031 197.593 103.839  28.440  38.062  21.598  23.345
  8   32.285  54.775  25.397 110.854  22.142   2.352   6.365  11.689  15.470
  9   13.560  11.200  12.698  56.976   2.584   0.511   0.358   1.312   1.346
  10   3.229   0.010   6.349  17.343   7.753   0.614   0.215   0.010   0.433
    year
age       2006    2007    2008    2009    2010
  1   11.133  14.033   4.466   0.010   5.909
  2   51.823  55.866  51.630  29.482   2.998
  3   69.308 104.918  55.749  78.764   9.613
  4   93.906 199.158 124.941  88.343  33.412
  5   69.287  95.846  78.982  57.212  59.136
  6   42.333  49.131  52.966  33.041  49.498
  7   36.280  17.616  27.798  41.209  27.791
  8    6.924   2.314   9.610   6.757  12.961
  9    8.984   2.255   1.596   0.971   4.343
  10   0.010   0.242   0.610   0.010   1.069

units:  NA

Slot "catch.wt":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

    year
age      1970   1971   1972   1973   1974   1975   1976   1977   1978   1979
  1    0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614
  2    1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083
  3    1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646
  4    2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292
  5    3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004
  6    3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731
  7    4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456
  8    5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170
  9    5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876
  10   7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458
    year
age      1980   1981   1982   1983   1984   1985   1986   1987   1988   1989
  1    0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.500
  2    1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.000
  3    1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.400
  4    2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292  1.800
  5    3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004  2.200
  6    3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.300
  7    4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.000
  8    5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.300
  9    5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876  6.600
  10   7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458 12.117
    year
age      1990   1991   1992   1993   1994   1995   1996   1997   1998   1999
  1    0.457  0.383  0.727  0.453  0.600  0.090  0.417  0.417  0.417  0.417
  2    0.730  0.777  0.947  0.893  0.760  0.720  0.822  0.822  0.822  0.822
  3    1.247  1.153  1.427  1.100  1.070  0.953  1.000  1.000  1.300  1.300
  4    1.777  1.710  1.997  1.543  1.593  1.570  1.600  1.600  1.700  1.700
  5    2.160  2.120  2.647  2.087  2.083  2.220  2.100  2.100  2.200  2.200
  6    3.243  3.030  3.907  2.963  2.597  2.993  2.800  2.800  3.100  3.100
  7    3.900  4.257  5.283  4.443  4.200  4.423  4.300  4.300  4.300  4.300
  8    5.447  5.467  6.300  5.820  5.900  6.000  6.000  6.000  6.000  6.000
  9    6.500  6.600  8.800  8.340  8.300  8.500  9.500  9.500  7.000  7.000
  10  12.278 12.352  9.537  9.369  9.473  9.500 10.314 10.500 10.314  9.500
    year
age      2000   2001   2002   2003   2004   2005   2006   2007   2008   2009
  1    0.180  0.417  0.417  0.477  0.486  0.160  0.621  0.291  0.380  0.365
  2    0.430  0.822  0.852  0.793  0.973  0.843  0.999  0.794  0.828  0.660
  3    1.227  1.300  1.283  1.292  1.429  1.321  1.507  1.400  1.456  1.155
  4    1.567  1.700  1.938  1.975  1.953  1.938  2.114  1.891  1.901  1.749
  5    2.223  2.300  2.532  2.400  2.517  2.545  2.680  2.441  2.466  2.423
  6    2.870  3.100  3.197  3.116  3.183  3.436  3.501  3.119  2.969  3.415
  7    3.913  4.100  4.117  4.078  4.238  4.388  4.467  4.706  3.863  4.197
  8    5.233  5.700  5.400  5.400  5.796  5.780  5.828  6.060  4.473  5.192
  9    6.620  9.500  6.600  6.600  6.800  7.500  7.400  7.500  5.697  6.323
  10   8.321 12.667 10.250 10.000 10.314  9.842 10.314  9.000  6.643  7.109
    year
age      2010
  1    0.350
  2    0.683
  3    1.188
  4    1.726
  5    2.511
  6    2.622
  7    3.846
  8    5.177
  9    5.999
  10   7.575

units:  NA


Slot "landings":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

     year
age   1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983
  all 5273 3052 3049 3705 1696 1273 1584 2012 2160 5447 2843 3276 4662 5307
     year
age   1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997
  all 2852  527  428  849 1116 1460 1393  935  439 1603 2144 2943 2048 1025
     year
age   1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
```

```
  all 1588 1953 2789 2557  618  424  434  741  967 1035  816  731  622

units:  NA

Slot "landings.n":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

    year
age       1970    1971    1972    1973    1974    1975    1976    1977    1978
  1    0.007   0.005   0.006   0.007   0.007   0.007   0.007   0.007   0.007
  2   65.448   1.603   1.795   3.276   2.194   0.191  26.854  21.541  21.158
  3  318.853  42.369  69.707  45.478   5.856  10.169  84.191  50.683  60.831
  4  154.938 383.684  47.675  59.883   9.269  27.845  34.046  23.844  47.355
  5  487.003 177.476 193.765 266.866  46.625 132.422 100.769  78.042 184.886
  6  279.973 166.641 200.337 228.830 107.847  90.576  90.356  99.064 126.636
  7  211.556 126.356 167.879 201.215 106.588  58.027  62.886  94.341  93.954
  8   75.540  37.246  69.337  74.841  37.904  17.713  18.565  31.332  28.841
  9   34.431  14.934  27.031  33.005  23.281   6.582  12.330  26.206  18.136
  10  37.472  13.741  30.643  47.736  41.964   9.060  33.429  68.366  30.290
    year
age       1979    1980    1981    1982    1983    1984    1985    1986    1987
  1    0.007   0.007   0.007   0.007   0.007   0.007   0.007   0.007   0.007
  2    3.487  12.592  19.347   0.069   0.069   0.070   0.068   0.071   0.068
  3  144.537  74.573  80.342 124.240 161.236  61.526   0.950   0.071   1.370
  4  103.382  40.556  25.763  74.443 100.617  56.603   2.756   0.286   9.591
  5  396.321 159.528  80.858 216.348 383.175  52.297   5.321   6.302  14.558
  6  323.636 190.027 145.410 183.627 216.700  86.136  10.356   7.377  55.147
  7  246.251 145.056 177.792 184.636 196.244  92.288  18.622  15.039  16.099
  8   76.020  48.488  97.042  82.350  79.163  75.676   8.836   0.287  15.756
  9   50.402  25.021  54.478  75.873  72.178  52.297  14.917   3.294   9.933
  10 105.125  51.106  88.998 168.654 153.253 138.432  33.253  39.317  48.810
    year
age        1988    1989    1990    1991    1992    1993    1994    1995    1996
  1    0.007   3.710  20.254  55.073  17.705 201.279   0.687  18.864  76.792
  2    0.067  11.804  56.517  70.661  42.675 436.461 122.823  67.184  38.396
  3    0.067  33.052  69.006 120.758  29.139 366.249 283.930  47.037  40.687
  4    0.268  41.147 105.994  87.588  29.625 150.765 224.630 311.408 130.189
  5   23.146  59.359  95.720  60.376  17.215  63.550 204.966 486.222 168.863
  6   35.031  68.128  37.479  47.027  13.473  25.902  62.968 246.691 210.143
  7   28.985  34.739  29.595  36.382  15.199  14.710  44.668  87.013  97.104
  8   45.249  16.863  20.983   8.410   9.901  14.699  39.514  18.741  42.477
  9   10.218  15.852  13.094   6.112   2.271  11.461  33.673   2.444   9.999
  10  65.891  52.614  36.052   6.112   2.453   3.249  10.323   2.444   0.011
    year
age       1997    1998    1999    2000    2001    2002    2003    2004    2005
  1    0.010   0.010   0.010   3.713   0.010   0.010   1.452   1.361   1.590
  2    0.010   0.010   0.010 110.151  28.426  33.198   9.230   7.401  27.498
  3   62.311   8.951  69.841  98.406  42.512  64.377  16.090  18.841  82.513
  4   48.751  25.789 114.285 132.503 133.008  48.754  14.999  23.199  84.500
  5   43.585  73.551  76.190 107.750 247.270  57.419  25.103  28.551  58.886
  6   50.365 176.184 184.125  78.666 322.937  40.028  35.504  31.623  28.294
  7   68.768  97.091 146.031 197.593 103.839  28.440  38.062  21.598  23.345
  8   32.285  54.775  25.397 110.854  22.142   2.352   6.365  11.689  15.470
  9   13.560  11.200  12.698  56.976   2.584   0.511   0.358   1.312   1.346
  10   3.229   0.010   6.349  17.343   7.753   0.614   0.215   0.010   0.433
    year
age       2006    2007    2008    2009    2010
  1   11.133  14.033   4.466   0.010   5.909
  2   51.823  55.866  51.630  29.482   2.998
  3   69.308 104.918  55.749  78.764   9.613
  4   93.906 199.158 124.941  88.343  33.412
  5   69.287  95.846  78.982  57.212  59.136
  6   42.333  49.131  52.966  33.041  49.498
  7   36.280  17.616  27.798  41.209  27.791
  8    6.924   2.314   9.610   6.757  12.961
  9    8.984   2.255   1.596   0.971   4.343
  10   0.010   0.242   0.610   0.010   1.069

units:  NA

Slot "landings.wt":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

    year
age       1970   1971   1972   1973   1974   1975   1976   1977   1978   1979
  1   0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614
  2   1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083
  3   1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646
  4   2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292
  5   3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004
  6   3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731
  7   4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456
  8   5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170
  9   5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876
  10  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458
    year
age       1980   1981   1982   1983   1984   1985   1986   1987   1988   1989
  1   0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.500
  2   1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.000
  3   1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.400
  4   2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292  1.800
  5   3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004  2.200
  6   3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.300
  7   4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.000
  8   5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.300
  9   5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876  6.600
  10  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458 12.117
    year
age        1990   1991   1992   1993   1994   1995   1996   1997   1998   1999
  1   0.457  0.383  0.727  0.453  0.600  0.090  0.417  0.417  0.417  0.417
  2   0.730  0.777  0.947  0.893  0.760  0.720  0.822  0.822  0.822  0.822
  3   1.247  1.153  1.427  1.100  1.070  0.953  1.000  1.000  1.300  1.300
  4   1.777  1.710  1.997  1.543  1.593  1.570  1.600  1.600  1.700  1.700
  5   2.160  2.120  2.647  2.087  2.083  2.220  2.100  2.100  2.200  2.200
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  6   3.243  3.030  3.907  2.963  2.597  2.993  2.800  2.800  3.100  3.100
  7   3.900  4.257  5.283  4.443  4.200  4.423  4.300  4.300  4.300  4.300
  8   5.447  5.467  6.300  5.820  5.900  6.000  6.000  6.000  6.000  6.000
  9   6.500  6.600  8.800  8.340  8.300  8.500  9.500  9.500  7.000  7.000
  10 12.278 12.352  9.537  9.369  9.473  9.500 10.314 10.500 10.314  9.500
    year
age      2000   2001   2002   2003   2004   2005   2006   2007   2008   2009
  1   0.180  0.417  0.417  0.477  0.486  0.160  0.621  0.291  0.380  0.365
  2   0.430  0.822  0.852  0.793  0.973  0.843  0.999  0.794  0.828  0.660
  3   1.227  1.300  1.283  1.292  1.429  1.321  1.507  1.400  1.456  1.155
  4   1.567  1.700  1.938  1.975  1.953  1.938  2.114  1.891  1.901  1.749
  5   2.223  2.300  2.532  2.400  2.517  2.545  2.680  2.441  2.466  2.423
  6   2.870  3.100  3.197  3.116  3.183  3.436  3.501  3.119  2.969  3.415
  7   3.913  4.100  4.117  4.078  4.238  4.388  4.467  4.706  3.863  4.197
  8   5.233  5.700  5.400  5.400  5.796  5.780  5.828  6.060  4.473  5.192
  9   6.620  9.500  6.600  6.600  6.800  7.500  7.400  7.500  5.697  6.323
  10  8.321 12.667 10.250 10.000 10.314  9.842 10.314  9.000  6.643  7.109
    year
age    2010
  1   0.350
  2   0.683
  3   1.188
  4   1.726
  5   2.511
  6   2.622
  7   3.846
  8   5.177
  9   5.999
  10  7.575

units:  NA

Slot "stock":
An object of class "FLQuant", unit = unique, season = all, area = unique

     year
age   1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983
  all 0    0    0    0    0    0    0    0    0    0    0    0    0    0
     year
age   1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997
  all 0    0    0    0    0    0    0    0    0    0    0    0    0    0
     year
age   1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  all 0    0    0    0    0    0    0    0    0    0    0    0    0

units:  NA * NA

Slot "stock.n":
An object of class "FLQuant", unit = unique, season = all, area = unique
 age     1970     1971     1972     1973     1974     1975
   1  1715.20  2130.40  2091.80  3284.70  4006.40  3539.20
   2  2099.40  1418.40  1761.70  1729.80  2716.30  3313.10
   3  2297.90  1676.60  1171.50  1455.20  1427.50  2244.30
   4  1354.90  1610.30  1347.90   905.40  1162.10  1175.20
   5  1423.50   979.59   982.77  1071.30   694.27   952.55
   6   758.39   734.28   648.69   636.50   643.28   531.74
   7   430.74   372.56   455.68   354.26   318.27   433.89
   8   156.51   163.82   193.19   224.17   109.98   166.27
   9    91.23    60.73   101.60    96.70   117.32    56.48
  10    98.31    55.52   114.38   138.62   210.33    77.45
      year
 age     1976     1977     1978     1979     1980     1981
   1  2953.50  3057.80  2025.40  1832.20   931.16   934.40
   2  2926.70  2442.40  2528.70  1674.90  1515.10   770.03
   3  2739.60  2395.90  2000.20  2071.90  1381.90  1241.50
   4  1846.70  2189.00  1935.20  1598.70  1581.90  1075.00
   5   946.51  1496.20  1788.50  1557.30  1228.10  1271.30
   6   667.30   691.08  1166.30  1310.90   927.40   870.50
   7   357.36   469.66   481.41   849.31   789.77   594.11
   8   306.04   238.33   302.60   312.67   478.41   521.19
   9   121.39   236.20   168.60   224.01   189.43   351.54
  10   328.00   614.01   280.60   464.44   385.39   571.73
      year
 age     1982     1983     1984     1985     1986     1987
   1   648.20   461.53   521.47   776.79   915.79   683.88
   2   772.70   536.03   381.66   431.23   642.37   757.31
   3   619.19   638.93   443.21   315.55   356.55   531.15
   4   953.61   399.06   381.75   310.57   260.09   294.79
   5   865.53   720.90   238.51   264.21   254.32   214.82
   6   977.79   519.01   247.70   149.68   213.66   204.58
   7   587.64   641.60   232.14   126.51   114.36   169.98
   8   329.63   318.05   352.12   108.05    87.68    80.90
   9   342.76   197.70   191.03   222.37    81.32    72.25
  10   757.41   415.77   502.05   494.37   968.43   353.58
      year
 age     1988     1989     1990     1991     1992     1993
   1   777.34  1434.80  2287.30  3549.50  3034.00  2295.00
   2   565.53   642.82  1183.10  1873.10  2885.20  2492.90
   3   626.20   467.61   520.85   926.99  1484.70  2347.20
   4   437.99   517.78   356.64   367.97   656.77  1201.30
   5   235.05   361.96   390.77   198.54   224.65   516.18
   6   164.41   173.33   245.34   236.10   109.28   170.12
   7   119.03   104.10    81.38   168.81   152.48    78.12
   8   125.92    72.08    54.50    40.39   106.51   112.28
```

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   9    52.57    62.99    44.27    25.99    25.75    79.08
  10   337.21   207.68   120.95    25.83    27.73    22.32
      year
 age      1994     1995     1996     1997     1998     1999
   1  1723.30   995.99  1632.90  1261.50   873.15   594.52
   2  1714.80  1424.50   806.49  1280.50  1043.20   722.05
   3  1664.60  1306.40  1116.90   632.02  1058.90   862.69
   4  1607.90  1118.40  1037.60   886.64   465.99   867.54
   5   856.31  1125.40   641.67   739.64   688.89   361.90
   6   369.07   521.74   488.53   377.08   572.02   502.80
   7   117.13   247.94   207.12   212.89   266.03   312.82
   8    51.22    56.24   125.91    82.98   113.52   131.70
   9    79.48     6.43    29.47    65.50    39.26    44.06
  10    24.09     6.36     0.03    15.51     0.03    21.87
      year
 age      2000     2001     2002     2003     2004     2005
   1   474.36   489.50   677.69   948.32   978.78   911.75
   2   491.64   388.90   404.79   560.41   782.90   808.17
   3   597.10   306.39   295.76   304.55   455.04   640.70
   4   649.90   404.29   214.72   186.03   237.22   359.17
   5   613.50   416.95   213.37   133.23   140.20   175.08
   6   229.99   409.35   119.94   124.24    87.34    89.98
   7   248.35   118.66    44.85    62.78    70.45    43.47
   8   125.89    25.69     3.70    11.22    17.31    38.62
   9    85.82     3.30     1.11     0.92     3.49     3.68
  10    25.57     9.60     1.32     0.55     0.03     1.17
      year
 age      2006     2007     2008     2009     2010
   1   642.05   377.60   116.00    63.83   418.08
   2   752.54   520.83   299.50    91.86    52.78
   3   643.32   575.19   379.90   200.72    49.16
   4   454.80   468.97   380.25   263.46    94.36
   5   220.17   290.70   206.71   200.83   137.54
   6    91.23   119.07   153.24    99.12   114.05
   7    48.68    36.95    53.79    78.56    51.92
   8    14.72     7.26    14.54    19.20    27.49
   9    17.87     5.88     3.90     3.28     9.73
  10     0.02     0.62     1.48     0.03     2.37


units:  NA

Slot "stock.wt":
An object of class "FLQuant", unit = unique, season = all, area = unique

    year
age    1970   1971   1972   1973   1974   1975   1976   1977   1978   1979
  1   0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614
  2   1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083
  3   1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646
  4   2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292
  5   3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004
  6   3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731
  7   4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456
  8   5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170
  9   5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876
  10  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458
    year
age    1980   1981   1982   1983   1984   1985   1986   1987   1988   1989
  1   0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.500
  2   1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.000
  3   1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.400
  4   2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292  1.800
  5   3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004  2.200
  6   3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.300
  7   4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.000
  8   5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.300
  9   5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876  6.600
  10  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458 12.117
    year
age        1990   1991   1992   1993   1994   1995   1996   1997   1998   1999
  1   0.457  0.383  0.727  0.453  0.600  0.090  0.614  0.614  0.614  0.614
  2   0.730  0.777  0.947  0.893  0.760  0.720  1.083  1.083  1.083  1.083
  3   1.247  1.153  1.427  1.100  1.070  0.953  1.000  1.000  1.300  1.300
  4   1.777  1.710  1.997  1.543  1.593  1.570  1.600  1.600  1.700  1.700
  5   2.160  2.120  2.647  2.087  2.083  2.220  2.100  2.100  2.200  2.200
  6   3.243  3.030  3.907  2.963  2.597  2.993  2.800  2.800  3.100  3.100
  7   3.900  4.257  5.283  4.443  4.200  4.423  4.300  4.300  4.300  4.300
  8   5.447  5.467  6.300  5.820  5.900  6.000  6.000  6.000  6.000  6.000
  9   6.500  6.600  8.800  8.340  8.300  8.500  9.500  9.500  7.000  7.000
  10 12.278 12.352  9.537  9.369  9.473  9.500  7.458 10.500 10.314  9.500
    year
age         2000   2001   2002   2003   2004   2005   2006   2007   2008   2009
  1   0.180  0.614  0.614  0.614  0.486  0.160  0.621  0.291  0.380  0.365
  2   1.083  1.083  0.852  0.793  0.973  0.843  0.999  0.794  0.828  0.660
  3   1.227  1.300  1.283  1.292  1.429  1.321  1.507  1.400  1.456  1.155
  4   1.567  1.700  1.938  1.975  1.953  1.938  2.114  1.891  1.901  1.749
  5   2.223  2.300  2.532  2.400  2.517  2.545  2.680  2.441  2.466  2.423
  6   2.870  3.100  3.197  3.116  3.183  3.436  3.501  3.119  2.969  3.415
  7   3.913  4.100  4.117  4.078  4.238  4.388  4.467  4.706  3.863  4.197
  8   5.233  5.700  5.400  5.400  5.796  5.780  5.828  6.060  4.473  5.192
  9   6.620  9.500  6.600  6.600  6.800  7.500  7.400  7.500  5.697  6.323
  10  8.321 12.667 10.250 10.000  7.458  9.842  7.458  9.000  6.643  7.109
    year
age    2010
  1   0.350
```

```
  2   0.683
  3   1.188
  4   1.726
  5   2.511
  6   2.622
  7   3.846
  8   5.177
  9   5.999
  10  7.575

units:  NA

Slot "m":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

    year
age  1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984
  1  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  2  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  3  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  4  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  5  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  6  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  7  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  8  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  9  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  10 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
    year
age  1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999
  1  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  2  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  3  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  4  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  5  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  6  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  7  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  8  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  9  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  10 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
    year
age  2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  1  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  2  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  3  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  4  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  5  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  6  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  7  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  8  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  9  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  10 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19

units:  NA

Slot "mat":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

    year
age  1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984
  1  0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
  2  0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
  3  0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40
  4  0.77 0.77 0.77 0.77 0.77 0.77 0.77 0.77 0.77 0.77 0.77 0.77 0.77 0.77 0.77
  5  0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95
  6  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  7  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  8  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  9  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  10 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
    year
age  1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999
  1  0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
  2  0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
  3  0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40
  4  0.77 0.77 0.77 0.77 0.77 0.77 0.77 0.77 0.77 0.77 0.77 0.77 0.77 0.77 0.77
  5  0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95
  6  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  7  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  8  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  9  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  10 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
    year
age  2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  1  0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
  2  0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
  3  0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40 0.40
  4  0.77 0.77 0.77 0.77 0.77 0.77 0.77 0.77 0.77 0.77 0.77
  5  0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95 0.95
  6  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  7  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  8  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  9  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  10 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00

units:  NA

Slot "harvest":
An object of class "FLQuant", unit = unique, season = all, area = unique
```

age	1970	1971	1972	1973	1974	1975
1	0.00	0.00	0.00	0.00	0.00	0.00
2	0.03	0.00	0.00	0.00	0.00	0.00

3	0.17	0.03	0.07	0.03	0.00	0.00
4	0.13	0.30	0.04	0.08	0.01	0.03
5	0.47	0.22	0.24	0.32	0.08	0.17
6	0.52	0.29	0.41	0.50	0.20	0.21
7	0.78	0.47	0.52	0.98	0.46	0.16
8	0.76	0.29	0.50	0.46	0.48	0.12
9	0.54	0.32	0.35	0.47	0.25	0.14
10	0.54	0.32	0.35	0.47	0.25	0.14

	year					
age	1976	1977	1978	1979	1980	1981
1	0.00	0.00	0.00	0.00	0.00	0.00
2	0.01	0.01	0.01	0.00	0.01	0.03
3	0.03	0.02	0.03	0.08	0.06	0.07
4	0.02	0.01	0.03	0.07	0.03	0.03
5	0.12	0.06	0.12	0.33	0.15	0.07
6	0.16	0.17	0.13	0.32	0.26	0.20
7	0.22	0.25	0.24	0.38	0.23	0.40
8	0.07	0.16	0.11	0.31	0.12	0.23
9	0.12	0.13	0.13	0.28	0.16	0.19
10	0.12	0.13	0.13	0.28	0.16	0.19

	year					
age	1982	1983	1984	1985	1986	1987
1	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00
3	0.25	0.33	0.17	0.00	0.00	0.00
4	0.09	0.32	0.18	0.01	0.00	0.04
5	0.32	0.88	0.28	0.02	0.03	0.08
6	0.23	0.61	0.48	0.08	0.04	0.35
7	0.42	0.41	0.57	0.18	0.16	0.11
8	0.32	0.32	0.27	0.09	0.00	0.24
9	0.28	0.51	0.36	0.08	0.05	0.16
10	0.28	0.51	0.36	0.08	0.05	0.16

	year					
age	1988	1989	1990	1991	1992	1993
1	0.00	0.00	0.01	0.02	0.01	0.10
2	0.00	0.02	0.05	0.04	0.02	0.21
3	0.00	0.08	0.16	0.15	0.02	0.19
4	0.00	0.09	0.40	0.30	0.05	0.15
5	0.11	0.20	0.31	0.41	0.09	0.15
6	0.27	0.57	0.18	0.25	0.15	0.18
7	0.31	0.46	0.51	0.27	0.12	0.23
8	0.50	0.30	0.55	0.26	0.11	0.16
9	0.24	0.32	0.39	0.30	0.10	0.17
10	0.24	0.32	0.39	0.30	0.10	0.17

	year					
age	1994	1995	1996	1997	1998	1999
1	0.00	0.02	0.05	0.00	0.00	0.00
2	0.08	0.05	0.05	0.00	0.00	0.00
3	0.21	0.04	0.04	0.11	0.01	0.09
4	0.17	0.37	0.15	0.06	0.06	0.16
5	0.31	0.64	0.34	0.07	0.12	0.26
6	0.21	0.73	0.64	0.16	0.41	0.52
7	0.54	0.49	0.72	0.44	0.51	0.72
8	1.89	0.46	0.46	0.56	0.76	0.24
9	0.63	0.54	0.47	0.26	0.38	0.38
10	0.63	0.54	0.47	0.26	0.38	0.38

	year					
age	2000	2001	2002	2003	2004	2005
1	0.01	0.00	0.00	0.00	0.00	0.00
2	0.28	0.08	0.09	0.02	0.01	0.04
3	0.20	0.17	0.27	0.06	0.05	0.15
4	0.25	0.45	0.29	0.09	0.11	0.30
5	0.21	1.06	0.35	0.23	0.25	0.46
6	0.47	2.02	0.46	0.38	0.51	0.42
7	2.08	3.28	1.20	1.10	0.41	0.89
8	3.45	2.95	1.20	0.98	1.36	0.58
9	1.31	1.98	0.70	0.56	0.53	0.51
10	1.31	1.98	0.70	0.56	0.53	0.51

	year				
age	2006	2007	2008	2009	2010
1	0.02	0.04	0.04	0.00	0.02
2	0.08	0.13	0.21	0.44	0.06
3	0.13	0.22	0.18	0.56	0.24
4	0.26	0.63	0.45	0.46	0.49
5	0.42	0.45	0.55	0.38	0.64
6	0.71	0.60	0.48	0.46	0.65
7	1.71	0.74	0.84	0.86	0.89
8	0.73	0.43	1.30	0.49	0.73
9	0.80	0.55	0.60	0.39	0.67
10	0.80	0.55	0.60	0.39	0.67

units: f

Slot "harvest.spwn":

```
An object of class "FLQuant", unit = unique, season = all, area = unique

    year
age  1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984
  1  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  2  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  3  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  4  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  6  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  7  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  8  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  9  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  10 0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
    year
age  1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999
  1  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  2  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  3  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  4  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  6  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  7  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  8  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  9  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  10 0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
    year
age  2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  1  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  2  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  3  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  4  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  6  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  7  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  8  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  9  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  10 0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5

units:  NA

Slot "m.spwn":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

    year
age  1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984
  1  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  2  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  3  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  4  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  5  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  6  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  7  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  8  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  9  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  10 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
    year
age  1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999
  1  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  2  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  3  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  4  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  5  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  6  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  7  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  8  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  9  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  10 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
    year
age  2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  1  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  2  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  3  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  4  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  5  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  6  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  7  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  8  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  9  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  10 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25

units:  NA

Slot "name":
[1] "BLACK SEA TURBOT Total,2010,COMBSEX,PLUSGROUP"

Slot "desc":
[1] "Imported from a VPA file. ( TURT_70_2010IND.DAT ).  Wed Oct 12 14:08:24 2011 + FLAssess:  + FLAssess: "

Slot "range":
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        1        10        10      1970      2010         4         8
```

The XSA estimated recruitment has two peaks in 1974 – 1976 and 1991 – 1992 and to lows in1983-84 and 2000. There is some rise in recruitment after 2001. Correspondingly, SSB attained higher values up to 20,000 t in 1977 – 1981 and very low values after 2000. For the recent period however the STECF EWG 11 16 Black Sea is aware of misreporting of actual catches which could have contributed to the underestimation of stock abundance. Fishing mortality F_{4-8} has a peak of F~2 in 2000-2001 and keeps as high as F = 0.6 - 0.8 thereafter (Fig. 6.2.4.1.3.2).

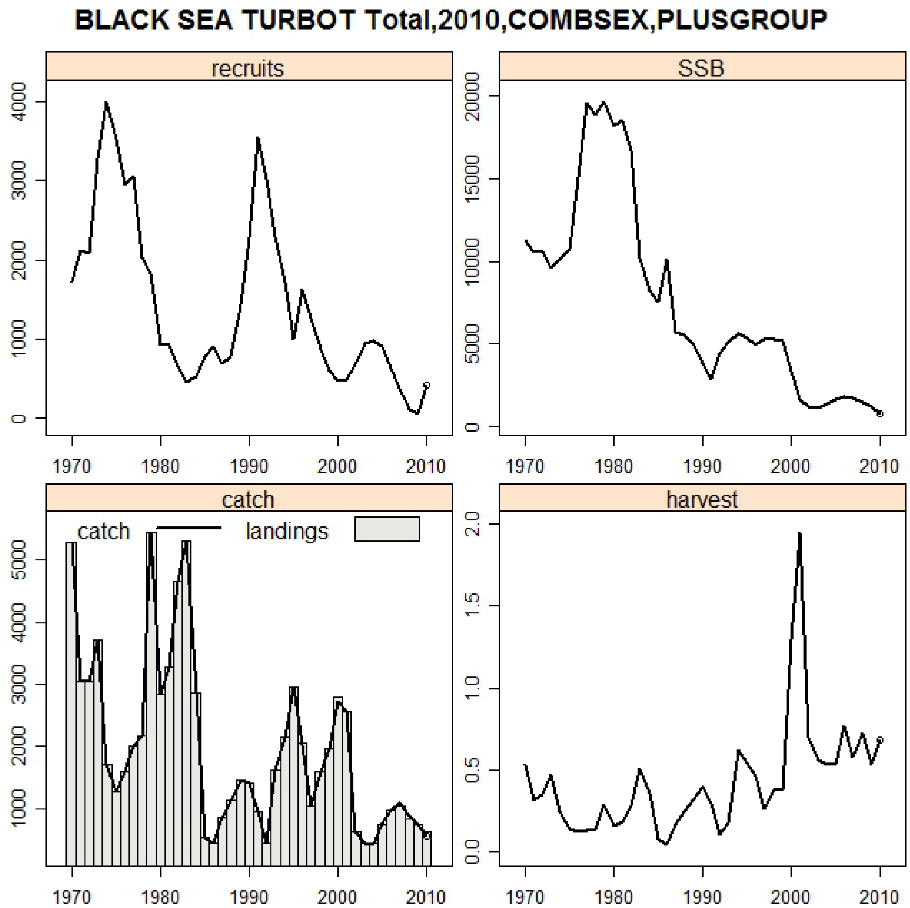

Fig. 6.2.4.1.3.1.2. Time-series of turbot population estimates of total stock in the Black Sea (XSA version with terminal F shrinkage): recruitment, SSB; landings and average fishing mortality (ages 4–8, line).

The STECF EWG Black Sea 11 16 made qualitative assumptions about the IUU (Illegal, Unregulated and Unreported) fishing of turbot and estimated the Potential Unreported Catch in 2002-2010.

The estimate of IUU catches of turbot was based on the fact that officially reported landings (mostly by Turkey) dropped suddenly in 2002 (Table 6.2.4.1.3.1). The STECF EWG Black Sea 11 16 realised that the much highest catch by Turkey until 2001 (between 1000 and 2000 t) has been actually taken illegaly from the north-western part of the Black Sea where are the main aggregations of the stock , transported and sold on the Turkish market and finally reported as Turkish catch (that actually it is). After 2001 Turkish turbot fishery had to rely only on the exausted turbot stock along the narrow southern Black Sea shelf (Turkish waters) and Turkish landings dropped to about 100-300 t on average (Table 6.2.4.1.3.1) leading to a substantial drop in the total reported landings. On the other hand, the STECF EWG Black Sea 11 16 has qualitative information that IUU fishing in Bulgarian, Romanian, and Ukrainian waters is a common practice and that unreported catches may exceed the officially reported by oredrs of magnitude. The STECF EWG Black Sea 11 16 than made the assumption that what has been caught by illegal Turkish fishermen is the Bulgarian, Romanian, and Ukrainian waters is now caught by the local fishermen and is named Potential Unreported Catch. It was estimated as a proportion between Turkish catch in 1993-2001 and 2009-2010, which then was used to rise the Turkish officially reported catch. The estimated total catch was about 2.44 times higher than the reported landings on average for 2002-2010. The STECF EWG Black Sea 11 16 considers this value as a maximum potential value and assumes that actual catch may lay in the region between the estimated and reported catch. Based on the estimated catches the historic assessment was run. The differences between the two assessments are during the last decade 2000-2010 when landings are considered as under-reported. The resulted recruitment and SSB were higher by 57% and 67% respectively, and the average fishing mortality (F4-8) lower by 13%.

The STECF EWG Black Sea 11 16 suggests that special investigations are performed in future in order to better identify the levels of IUU of turbot for the needs of stock assessment.

Because of uncertainties about actual catch the STECF EWG Black Sea 11 16 interprets the assessment only in relative terms – i.e. they are considered indicative of trends only.

The effect of tuning series was examined, but no significant difference was observed. The STECF EWG Black Sea 11 16 decided to apply only Bulgarian and Romanian tuning series. Results of analisys are presented on Fig. 6.2.4.1.3.3 and the resudials of tuning series - on Fig. 6.2.4.1.3.4.

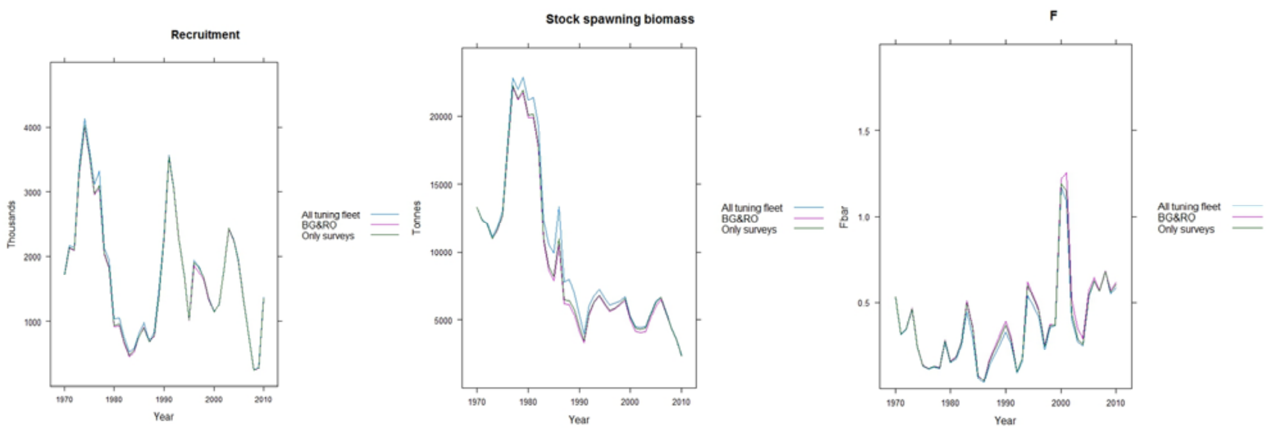

Fig. 6.2.4.1.3.3. Sensitivity analisys of the effect of tunning series over recruitment, SSB and F with estimated IUU landings.

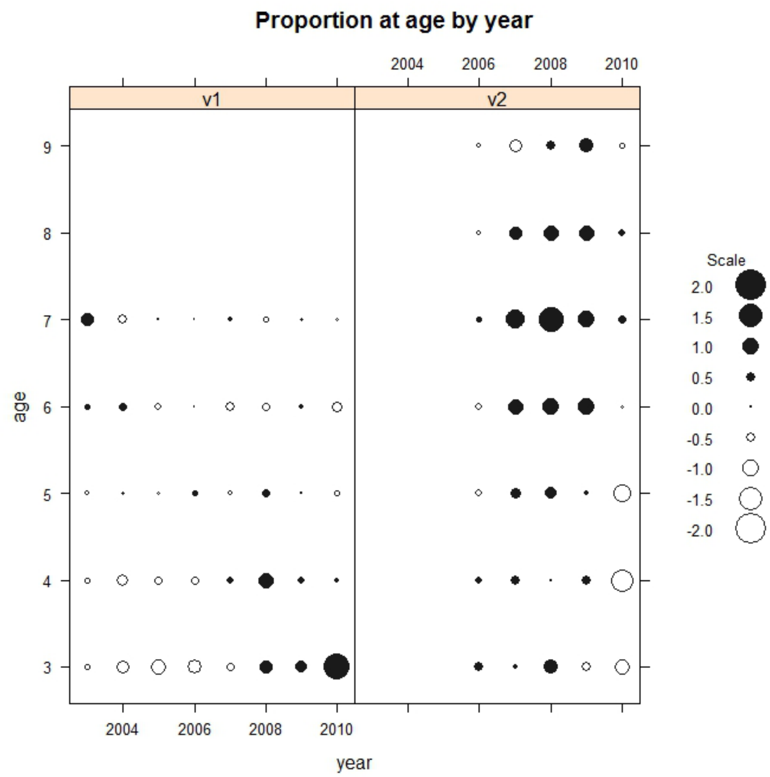

Fig. 6.2.4.1.3.4. Residuals of tuning series (IUU included): v1 - Romania, v2 - Bulgaria.

Biomass of turbot is low compared to historical levels. The drop in abundance is consistent with the decreases in CPUE and landings. Recruitment has increased in 2004-2006 and positively influenced the SSB, but given the high exploitation rate such a positive influence may not propagate in the next years. Fishing mortality of turbot is rather high: F =0.57 – 0.68 (given that M=0.19) - 6.2.4.1.3.3.

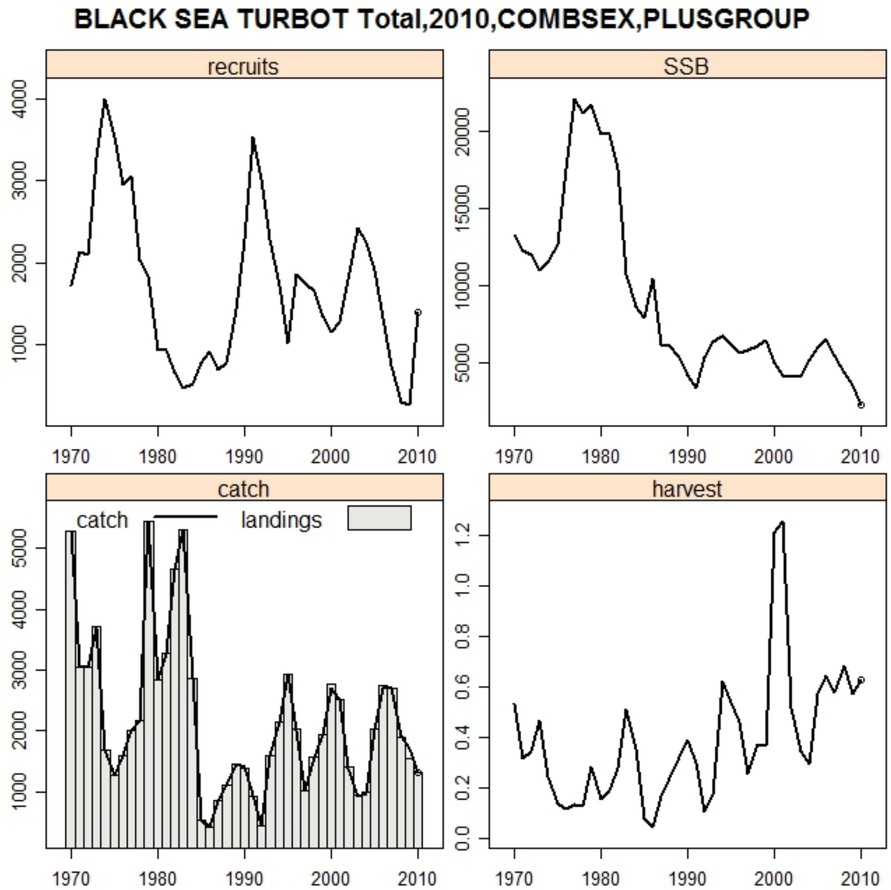

Fig. 6.2.4.1.3.3. Time-series of turbot population estimates of total stock in the Black Sea including estimated IUU catches (XSA version with terminal F shrinkage): recruitment, SSB, landings and average fishing mortality (ages 4–8).

Fig6.2.4.1.3.4. illustrates the retrospective behaviour of the fishing mortality (average over ages 4-8), SSB and recruitment. with IUU catches included. The retrospective runs underestimate recruitment, SSB and overestimate fishing mortality.

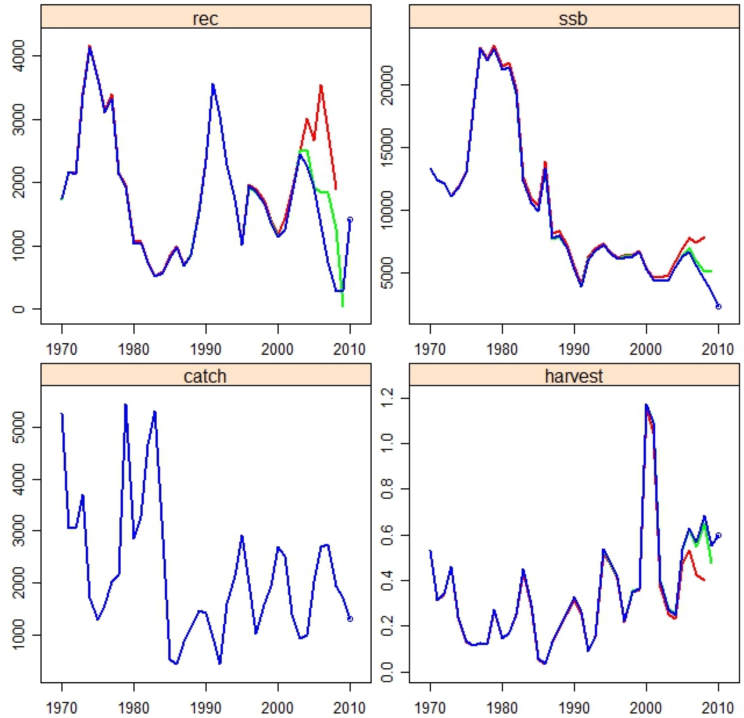

Fig. 6.2.4.1.3.4. Turbot in the Black Sea. Retrospective trends of the assessment parameters fishing mortality (average over ages 4-8), SSB and recruitment with IUU catch included.

XSA outputs including IUU catches are listed in the Tab. 6.2.4.1.3.2.

Tab. 6.2.4.1.3.2. Turbot in the Black Sea. XSA results and diagnostics including IUU catch.

Diagnostics

```
FLR XSA Diagnostics 2011-10-12 13:42:04
CPUE data from bst.idx[c(1, 3)]
Catch data for 41 years 1970 to 2010. Ages 1 to 10.

            fleet first age last age first year last year alpha beta
1  RO Trawl fleet         3        7       2003      2010  <NA> <NA>
2 BG Trawl survey         3        9       2006      2010  <NA> <NA>


 Time series weights :
    Tapered time weighting not applied

 Catchability analysis :
     Catchability independent of size for ages >   2
     Catchability independent of age for ages >   5

 Terminal population estimation :
     Survivor estimates shrunk towards the mean F
    of the final   5 years or the  5 oldest ages.

    S.E. of the mean to which the estimates are shrunk =   0.5

    Minimum standard error for population
    estimates derived from each fleet =  0.3
    prior weighting not applied

Regression weights
     year
          age   2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  all    1    1    1    1    1    1    1    1    1    1


 Fishing mortalities
    year
age   2001  2002  2003  2004  2005  2006  2007  2008  2009  2010
  1  0.000 0.000 0.001 0.001 0.001 0.013 0.023 0.019 0.000 0.011
```

2	0.033	0.088	0.015	0.007	0.030	0.054	0.094	0.138	0.196	0.036
3	0.058	0.245	0.048	0.034	0.067	0.108	0.201	0.145	0.345	0.169
4	0.189	0.212	0.066	0.085	0.175	0.316	0.612	0.345	0.308	0.420
5	0.532	0.282	0.149	0.195	0.291	0.473	0.491	0.507	0.326	0.561
6	1.208	0.373	0.267	0.309	0.419	0.665	0.501	0.385	0.471	0.575
7	2.354	0.834	0.749	0.330	1.039	1.389	0.722	0.903	1.062	0.822
8	2.009	0.891	0.496	0.545	0.942	0.393	0.553	1.276	0.707	0.764
9	1.273	0.522	0.347	0.294	0.494	0.710	0.673	0.593	0.453	0.642
10	1.273	0.522	0.347	0.294	0.494	0.710	0.673	0.593	0.453	0.642

XSA population number (Thousand)

year \ age	1	2	3	4	5	6	7	8	9	10
2001	1264	943	815	840	651	500	125	28	4	11
2002	1789	1046	755	635	575	316	124	10	3	4
2003	2429	1480	792	489	425	359	180	44	3	2
2004	2251	2007	1205	624	378	303	227	70	22	0
2005	1906	1859	1647	963	474	258	184	135	34	11
2006	1328	1575	1493	1274	669	293	140	54	44	0
2007	736	1084	1234	1108	768	345	125	29	30	3
2008	289	594	816	834	497	389	173	50	14	6
2009	264	235	428	584	489	248	219	58	12	0
2010	1393	218	160	251	355	292	128	63	24	6

Estimated population abundance at 1st Jan 2011

year \ age	1	2	3	4	5	6	7	8	9	10
2011	0	1140	174	112	136	167	136	46	24	10

Fleet: RO Trawl fleet

Log catchability residuals.

age \ year	2003	2004	2005	2006	2007	2008	2009	2010
3	-0.272	-0.753	-0.982	-0.887	-0.411	0.822	0.734	1.749
4	-0.246	-0.698	-0.457	-0.411	0.384	0.928	0.337	0.163
5	-0.193	0.117	-0.094	0.231	-0.201	0.438	0.006	-0.304
6	0.292	0.449	-0.388	-0.036	-0.541	-0.425	0.154	-0.622
7	0.827	-0.519	0.039	-0.018	0.144	-0.259	0.081	-0.119

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

	3	4	5	6	7
Mean_Logq	-1.8963	-1.4906	-1.2137	-1.2137	-1.2137
S.E_Logq	0.9882	0.5443	0.2501	0.4081	0.3892

Fleet: BG Trawl survey

Log catchability residuals.

age \ year	2006	2007	2008	2009	2010
3	0.507	0.162	0.867	-0.534	-1.002
4	0.368	0.553	0.028	0.527	-1.475
5	-0.323	0.651	0.675	0.143	-1.146
6	-0.368	0.983	1.084	1.023	-0.081
7	0.219	1.257	1.639	1.033	0.429
8	-0.168	0.795	0.966	0.976	0.386
9	-0.202	-0.794	0.535	0.849	-0.242

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

	3	4	5	6	7	8	9
Mean_Logq	-2.2553	-1.6987	-1.1501	-1.1501	-1.1501	-1.1501	-1.1501
S.E_Logq	0.7622	0.8508	0.7612	0.6954	0.5866	0.4869	0.6580

Terminal year survivor and F summaries:

,Age 1 Year class =2009

source	scaledWts	survivors	yrcls
fshk	0.642	1117	2009
nshk	0.358	1182	2009

,Age 2 Year class =2008

source	scaledWts	survivors	yrcls
fshk	1	59	2008

,Age 3 Year class =2007

source	scaledWts	survivors	yrcls
RO Trawl fleet	0.129	642	2007
BG Trawl survey	0.203	41	2007
fshk	0.669	108	2007

,Age 4 Year class =2006

source	scaledWts	survivors	yrcls
RO Trawl fleet	0.293	160	2006
BG Trawl survey	0.112	31	2006
fshk	0.595	168	2006

```
 ,Age 5 Year class =2005

source
                scaledWts survivors yrcls
RO Trawl fleet      0.568       124  2005
BG Trawl survey     0.074        53  2005
fshk                0.359       241  2005

 ,Age 6 Year class =2004

source
                scaledWts survivors yrcls
RO Trawl fleet      0.367        73  2004
BG Trawl survey     0.078       125  2004
fshk                0.555       166  2004

 ,Age 7 Year class =2003

source
                scaledWts survivors yrcls
RO Trawl fleet      0.376        41  2003
BG Trawl survey     0.039        71  2003
fshk                0.585        33  2003

 ,Age 8 Year class =2002

source
                scaledWts survivors yrcls
BG Trawl survey     0.126        35  2002
fshk                0.874        23  2002

 ,Age 9 Year class =2001

source
                scaledWts survivors yrcls
BG Trawl survey     0.202         8  2001
fshk                0.798        10  2001
```

Summary

```
An object of class "FLStock"
Slot "catch":
An object of class "FLQuant", unit = unique, season = all, area = unique

     year
age   1970    1971    1972    1973    1974    1975    1976    1977    1978
  all 5273.39 3051.59 3049.39 3704.59 1696.39 1272.89 1583.49 2011.68 2159.70
     year
age   1979    1980    1981    1982    1983    1984    1985    1986    1987
  all 5447.18 2842.78 3275.48 4662.36 5306.47 2851.76  526.90  428.39  849.39
     year
age   1988    1989    1990    1991    1992    1993    1994    1995    1996
  all 1115.58 1451.89 1409.69  952.19  438.05 1600.75 2138.88 2923.88 2006.10
     year
age   1997    1998    1999    2000    2001    2002    2003    2004    2005
  all 1014.01 1574.11 1933.01 2692.71 2519.31 1397.51  931.46  979.79 2030.12
     year
age   2006    2007    2008    2009    2010
  all 2694.77 2734.71 1923.49 1699.47 1312.06

units:  NA NA

Slot "catch.n":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

    year
age        1970    1971    1972    1973    1974    1975    1976    1977    1978
  1    0.007   0.005   0.006   0.007   0.007   0.007   0.007   0.007   0.007
  2   65.448   1.603   1.795   3.276   2.194   0.191  26.854  21.541  21.158
  3  318.853  42.369  69.707  45.478   5.856  10.169  84.191  50.683  60.831
  4  154.938 383.684  47.675  59.883   9.269  27.845  34.046  23.844  47.355
  5  487.003 177.476 193.765 266.866  46.625 132.422 100.769  78.042 184.886
  6  279.973 166.641 200.337 228.830 107.847  90.576  90.356  99.064 126.636
  7  211.556 126.356 167.879 201.215 106.588  58.027  62.886  94.341  93.954
  8   75.540  37.246  69.337  74.841  37.904  17.713  18.565  31.332  28.841
  9   34.431  14.934  27.031  33.005  23.281   6.582  12.330  26.206  18.136
  10  37.472  13.741  30.643  47.736  41.964   9.060  33.429  68.366  30.290
    year
age        1979    1980    1981    1982    1983    1984    1985    1986    1987
  1    0.007   0.007   0.007   0.007   0.007   0.007   0.007   0.007   0.007
  2    3.487  12.592  19.347   0.069   0.069   0.070   0.068   0.071   0.068
  3  144.537  74.573  80.342 124.240 161.236  61.526   0.950   0.071   1.370
  4  103.382  40.556  25.763  74.443 100.617  56.603   2.756   0.286   9.591
  5  396.321 159.528  80.858 216.348 383.175  52.297   5.321   6.302  14.558
  6  323.636 190.027 145.410 183.627 216.700  86.136  10.356   7.377  55.147
  7  246.251 145.056 177.792 184.636 196.244  92.288  18.622  15.039  16.099
  8   76.020  48.488  97.042  82.350  79.163  75.676   8.836   0.287  15.756
  9   50.402  25.021  54.478  75.873  72.178  52.297  14.917   3.294   9.933
  10 105.125  51.106  88.998 168.654 153.253 138.432  33.253  39.317  48.810
    year
age        1988    1989    1990    1991    1992    1993    1994    1995    1996
  1    0.007   3.690  20.240  55.073  17.696 201.028   0.686  18.742  76.147
  2    0.067  11.740  56.477  70.661  42.652 435.916 122.536  66.750  38.073
  3    0.067  32.871  68.957 120.758  29.123 365.792 283.268  46.733  40.346
  4    0.268  40.921 105.919  87.588  29.609 150.577 224.106 309.398 129.095
  5   23.146  59.034  95.652  60.376  17.205  63.471 204.488 483.083 167.444
  6   35.031  67.755  37.452  47.027  13.466  25.870  62.821 245.099 208.377
  7   28.985  34.548  29.574  36.382  15.191  14.691  44.564  86.452  96.288
  8   45.249  16.771  20.968   8.410   9.896  14.680  39.422  18.620  42.120
  9   10.218  15.765  13.084   6.112   2.270  11.447  33.594   2.429   9.915
  10  65.891  52.326  36.027   6.112   2.451   3.245  10.299   2.429   0.011
    year
age        1997    1998    1999    2000    2001    2002    2003    2004    2005
  1    0.010   0.010   0.010   3.680   0.010   0.010   2.537   1.821   1.559
```

```
  2    0.010   0.010   0.010 109.187  28.092  79.961  20.471  13.265  49.463
  3   61.642   8.872  69.125  97.545  42.012 148.930  33.582  36.709  96.474
  4   48.228  25.562 113.114 131.344 131.444 110.457  28.226  46.228 140.665
  5   43.118  72.902  75.410 106.807 244.364 128.754  53.471  60.885 108.857
  6   49.825 174.631 182.240  77.977 319.142  89.635  76.362  73.196  80.221
  7   68.030  96.235 144.535 195.864 102.619  63.578  86.349  58.005 108.083
  8   31.939  54.292  25.137 109.884  21.882   5.250  15.796  26.890  74.992
  9   13.414  11.101  12.568  56.477   2.554   1.141   0.887   5.183  11.970
  10   3.194   0.010   6.284  17.191   7.661   1.369   0.532   0.010   3.855
    year
age        2006    2007    2008    2009    2010
  1   15.658  15.453   4.864   0.010  13.855
  2   75.550  88.621  69.507  37.942   7.029
  3  139.291 204.394  99.938 113.510  22.538
  4  314.086 461.007 221.254 140.696  78.335
  5  228.944 271.085 179.560 123.510 138.648
  6  129.574 123.520 113.044  84.591 116.050
  7   95.583  58.256  93.380 130.151  65.159
  8   15.879  11.151  32.830  26.686  30.389
  9   20.130  13.378   5.583   3.833  10.183
  10   0.000   1.433   2.465   0.010   2.507

units:  NA

Slot "catch.wt":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

    year
age        1970   1971   1972   1973   1974   1975   1976   1977   1978   1979
  1   0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614
  2   1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083
  3   1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646
  4   2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292
  5   3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004
  6   3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731
  7   4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456
  8   5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170
  9   5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876
  10  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458
    year
age        1980   1981   1982   1983   1984   1985   1986   1987   1988   1989
  1   0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.500
  2   1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.000
  3   1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.400
  4   2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292  1.800
  5   3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004  2.200
  6   3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.300
  7   4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.000
  8   5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.300
  9   5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876  6.600
  10  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458 12.117
    year
age        1990   1991   1992   1993   1994   1995   1996   1997   1998   1999
  1   0.457  0.383  0.727  0.453  0.600  0.090  0.417  0.417  0.417  0.417
  2   0.730  0.777  0.947  0.893  0.760  0.720  0.822  0.822  0.822  0.822
  3   1.247  1.153  1.427  1.100  1.070  0.953  1.000  1.000  1.300  1.300
  4   1.777  1.710  1.997  1.543  1.593  1.570  1.600  1.600  1.700  1.700
  5   2.160  2.120  2.647  2.087  2.083  2.220  2.100  2.100  2.200  2.200
  6   3.243  3.030  3.907  2.963  2.597  2.993  2.800  2.800  3.100  3.100
  7   3.900  4.257  5.283  4.443  4.200  4.423  4.300  4.300  4.300  4.300
  8   5.447  5.467  6.300  5.820  5.900  6.000  6.000  6.000  6.000  6.000
  9   6.500  6.600  8.800  8.340  8.300  8.500  9.500  9.500  7.000  7.000
  10 12.278 12.352  9.537  9.369  9.473  9.500 10.314 10.500 10.314  9.500
    year
age        2000   2001   2002   2003   2004   2005   2006   2007   2008   2009
  1   0.180  0.417  0.417  0.477  0.486  0.160  0.621  0.291  0.213  0.365
  2   0.430  0.822  0.852  0.793  0.973  0.843  0.999  0.794  0.571  0.660
  3   1.227  1.300  1.283  1.292  1.429  1.321  1.507  1.400  1.356  1.155
  4   1.567  1.700  1.938  1.975  1.953  1.938  2.114  1.891  1.791  1.749
  5   2.223  2.300  2.532  2.400  2.517  2.545  2.680  2.441  2.420  2.423
  6   2.870  3.100  3.197  3.116  3.183  3.436  3.501  3.119  3.001  3.415
  7   3.913  4.100  4.117  4.078  4.238  4.388  4.467  4.706  4.015  4.197
  8   5.233  5.700  5.400  5.400  5.796  5.780  5.828  6.060  4.694  5.192
  9   6.620  9.500  6.600  6.600  6.800  7.500  7.400  7.500  5.697  6.323
  10  8.321 12.667 10.250 10.000 10.314  9.842  0.000  9.000  6.643  7.109
    year
age    2010
  1   0.350
  2   0.683
  3   1.188
  4   1.726
  5   2.511
  6   2.622
  7   3.846
  8   5.177
  9   5.999
  10  7.575

units:  NA

Slot "landings":
An object of class "FLQuant", unit = unique, season = all, area = unique

     year
age   1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983
  all 5273 3052 3049 3705 1696 1273 1584 2012 2160 5447 2843 3276 4662 5307
     year
age   1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997
  all 2852  527  428  849 1116 1452 1392  935  438 1601 2139 2924 2031 1014
     year
age   1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  all 1574 1933 2776 2522 1412  943  989 2039 2737 2692 1901 1541 1321

units:  NA
```

```
Slot "landings.n":
An object of class "FLQuant", unit = unique, season = all, area = unique

    year
age        1970    1971    1972    1973    1974    1975    1976    1977    1978
  1    0.007   0.005   0.006   0.007   0.007   0.007   0.007   0.007   0.007
  2   65.448   1.603   1.795   3.276   2.194   0.191  26.854  21.541  21.158
  3  318.853  42.369  69.707  45.478   5.856  10.169  84.191  50.683  60.831
  4  154.938 383.684  47.675  59.883   9.269  27.845  34.046  23.844  47.355
  5  487.003 177.476 193.765 266.866  46.625 132.422 100.769  78.042 184.886
  6  279.973 166.641 200.337 228.830 107.847  90.576  90.356  99.064 126.636
  7  211.556 126.356 167.879 201.215 106.588  58.027  62.886  94.341  93.954
  8   75.540  37.246  69.337  74.841  37.904  17.713  18.565  31.332  28.841
  9   34.431  14.934  27.031  33.005  23.281   6.582  12.330  26.206  18.136
  10  37.472  13.741  30.643  47.736  41.964   9.060  33.429  68.366  30.290
    year
age        1979    1980    1981    1982    1983    1984    1985    1986    1987
  1    0.007   0.007   0.007   0.007   0.007   0.007   0.007   0.007   0.007
  2    3.487  12.592  19.347   0.069   0.069   0.070   0.068   0.071   0.068
  3  144.537  74.573  80.342 124.240 161.236  61.526   0.950   0.071   1.370
  4  103.382  40.556  25.763  74.443 100.617  56.603   2.756   0.286   9.591
  5  396.321 159.528  80.858 216.348 383.175  52.297   5.321   6.302  14.558
  6  323.636 190.027 145.410 183.627 216.700  86.136  10.356   7.377  55.147
  7  246.251 145.056 177.792 184.636 196.244  92.288  18.622  15.039  16.099
  8   76.020  48.488  97.042  82.350  79.163  75.676   8.836   0.287  15.756
  9   50.402  25.021  54.478  75.873  72.178  52.297  14.917   3.294   9.933
  10 105.125  51.106  88.998 168.654 153.253 138.432  33.253  39.317  48.810
    year
age        1988    1989    1990    1991    1992    1993    1994    1995    1996
  1    0.007   3.690  20.240  55.073  17.696 201.028   0.686  18.742  76.147
  2    0.067  11.740  56.477  70.661  42.652 435.916 122.536  66.750  38.073
  3    0.067  32.871  68.957 120.758  29.123 365.792 283.268  46.733  40.346
  4    0.268  40.921 105.919  87.588  29.609 150.577 224.106 309.398 129.095
  5   23.146  59.034  95.652  60.376  17.205  63.471 204.488 483.083 167.444
  6   35.031  67.755  37.452  47.027  13.466  25.870  62.821 245.099 208.377
  7   28.985  34.548  29.574  36.382  15.191  14.691  44.564  86.452  96.288
  8   45.249  16.771  20.968   8.410   9.896  14.680  39.422  18.620  42.120
  9   10.218  15.765  13.084   6.112   2.270  11.447  33.594   2.429   9.915
  10  65.891  52.326  36.027   6.112   2.451   3.245  10.299   2.429   0.011
    year
age        1997    1998    1999    2000    2001    2002    2003    2004    2005
  1    0.010   0.010   0.010   3.680   0.010   0.010   2.537   1.821   1.559
  2    0.010   0.010   0.010 109.187  28.092  79.961  20.471  13.265  49.463
  3   61.642   8.872  69.125  97.545  42.012 148.930  33.582  36.709  96.474
  4   48.228  25.562 113.114 131.344 131.444 110.457  28.226  46.228 140.665
  5   43.118  72.902  75.410 106.807 244.364 128.754  53.471  60.885 108.857
  6   49.825 174.631 182.240  77.977 319.142  89.635  76.362  73.196  80.221
  7   68.030  96.235 144.535 195.864 102.619  63.578  86.349  58.005 108.083
  8   31.939  54.292  25.137 109.884  21.882   5.250  15.796  26.890  74.992
  9   13.414  11.101  12.568  56.477   2.554   1.141   0.887   5.183  11.970
  10   3.194   0.010   6.284  17.191   7.661   1.369   0.532   0.010   3.855
    year
age        2006    2007    2008    2009    2010
  1   15.658  15.453   4.864   0.010  13.855
  2   75.550  88.621  69.507  37.942   7.029
  3  139.291 204.394  99.938 113.510  22.538
  4  314.086 461.007 221.254 140.696  78.335
  5  228.944 271.085 179.560 123.510 138.648
  6  129.574 123.520 113.044  84.591 116.050
  7   95.583  58.256  93.380 130.151  65.159
  8   15.879  11.151  32.830  26.686  30.389
  9   20.130  13.378   5.583   3.833  10.183
  10   0.000   1.433   2.465   0.010   2.507

units:  NA

Slot "landings.wt":
An object of class "FLQuant", unit = unique, season = all, area = unique

    year
age      1970   1971   1972   1973   1974   1975   1976   1977   1978   1979
  1   0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614
  2   1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083
  3   1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646
  4   2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292
  5   3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004
  6   3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731
  7   4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456
  8   5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170
  9   5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876
  10  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458
    year
age      1980   1981   1982   1983   1984   1985   1986   1987   1988   1989
  1   0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.614  0.500
  2   1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.083  1.000
  3   1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.646  1.400
  4   2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292  2.292  1.800
  5   3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004  3.004  2.200
  6   3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.731  3.300
  7   4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.456  4.000
  8   5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.170  5.300
  9   5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876  5.876  6.600
  10  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458  7.458 12.117
    year
age      1990   1991   1992   1993   1994   1995   1996   1997   1998   1999
  1   0.457  0.383  0.727  0.453  0.600  0.090  0.417  0.417  0.417  0.417
  2   0.730  0.777  0.947  0.893  0.760  0.720  0.822  0.822  0.822  0.822
  3   1.247  1.153  1.427  1.100  1.070  0.953  1.000  1.000  1.300  1.300
  4   1.777  1.710  1.997  1.543  1.593  1.570  1.600  1.600  1.700  1.700
  5   2.160  2.120  2.647  2.087  2.083  2.220  2.100  2.100  2.200  2.200
  6   3.243  3.030  3.907  2.963  2.597  2.993  2.800  2.800  3.100  3.100
  7   3.900  4.257  5.283  4.443  4.200  4.423  4.300  4.300  4.300  4.300
  8   5.447  5.467  6.300  5.820  5.900  6.000  6.000  6.000  6.000  6.000
  9   6.500  6.600  8.800  8.340  8.300  8.500  9.500  9.500  7.000  7.000
  10 12.278 12.352  9.537  9.369  9.473  9.500 10.314 10.500 10.314  9.500
    year
```

age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0.180	0.417	0.417	0.477	0.486	0.160	0.621	0.291	0.213	0.365
2	0.430	0.822	0.852	0.793	0.973	0.843	0.999	0.794	0.571	0.660
3	1.227	1.300	1.283	1.292	1.429	1.321	1.507	1.400	1.356	1.155
4	1.567	1.700	1.938	1.975	1.953	1.938	2.114	1.891	1.791	1.749
5	2.223	2.300	2.532	2.400	2.517	2.545	2.680	2.441	2.420	2.423
6	2.870	3.100	3.197	3.116	3.183	3.436	3.501	3.119	3.001	3.415
7	3.913	4.100	4.117	4.078	4.238	4.388	4.467	4.706	4.015	4.197
8	5.233	5.700	5.400	5.400	5.796	5.780	5.828	6.060	4.694	5.192
9	6.620	9.500	6.600	6.600	6.800	7.500	7.400	7.500	5.697	6.323
10	8.321	12.667	10.250	10.000	10.314	9.842	0.000	9.000	6.643	7.109

	year
age	2010
1	0.350
2	0.683
3	1.188
4	1.726
5	2.511
6	2.622
7	3.846
8	5.177
9	5.999
10	7.575

```
units:  NA

Slot "stock":
An object of class "FLQuant", unit = unique, season = all, area = unique

     year
age   1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983
  all   0    0    0    0    0    0    0    0    0    0    0    0    0    0
     year
age   1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997
  all   0    0    0    0    0    0    0    0    0    0    0    0    0    0
     year
age   1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  all   0    0    0    0    0    0    0    0    0    0    0    0    0

units:  NA * NA

Slot "stock.n":
An object of class "FLQuant", unit = unique, season = all, area = unique
```

year						
age	1970	1971	1972	1973	1974	1975
1	1715	2130	2092	3284	4006	3539
2	2099	1418	1762	1730	2716	3313
3	2298	1677	1171	1455	1427	2244
4	1355	1610	1348	905	1162	1175
5	1424	980	983	1071	694	952
6	758	734	649	636	643	532
7	431	373	456	354	318	434
8	157	164	193	224	110	166
9	91	61	102	97	117	56
10	98	56	114	139	210	77
year						
age	1976	1977	1978	1979	1980	1981
1	2952.60	3056.40	2024.80	1831.60	930.65	933.57
2	2926.30	2441.70	2527.50	1674.40	1514.70	769.60
3	2739.20	2395.50	1999.60	2070.90	1381.50	1241.10
4	1846.40	2188.60	1934.90	1598.30	1581.10	1074.70
5	946.39	1495.90	1788.20	1557.00	1227.70	1270.60
6	667.22	690.99	1166.10	1310.70	927.21	870.18
7	357.31	469.60	481.34	849.14	789.55	593.96
8	306.00	238.30	302.55	312.61	478.27	521.02
9	121.38	236.17	168.57	223.97	189.38	351.42
10	327.96	613.92	280.56	464.35	385.28	571.54
year						
age	1982	1983	1984	1985	1986	1987
1	647.47	460.56	520.00	774.66	913.74	682.82
2	772.02	535.43	380.85	430.01	640.60	755.62
3	618.83	638.37	442.72	314.89	355.54	529.69
4	953.29	398.77	381.28	310.16	259.54	293.95
5	865.27	720.64	238.27	263.83	253.98	214.37
6	977.23	518.80	247.49	149.48	213.34	204.30
7	587.37	641.14	231.96	126.33	114.20	169.71
8	329.50	317.83	351.74	107.90	87.54	80.76
9	342.61	197.60	190.84	222.06	81.19	72.13
10	757.09	415.55	501.57	493.67	966.97	352.98
year						
age	1988	1989	1990	1991	1992	1993
1	775.55	1429.90	2277.20	3533.00	3028.20	2279.80
2	564.66	641.34	1179.10	1864.80	2871.60	2488.10
3	624.80	466.89	519.69	923.73	1477.80	2335.90
4	436.78	516.62	356.21	367.05	654.08	1195.60
5	234.36	360.96	390.01	198.25	223.89	513.97
6	164.03	172.76	244.81	235.54	109.04	169.50
7	118.80	103.79	81.25	168.39	152.02	77.93
8	125.71	71.88	54.42	40.30	106.17	111.90
9	52.46	62.81	44.19	25.93	25.68	78.80
10	336.48	207.09	120.75	25.77	27.64	22.24

age \ year	1994	1995	1996	1997	1998	1999
1	1716.30	1009.00	1863.10	1759.30	1643.00	1336.70
2	1702.50	1418.70	817.34	1471.50	1454.80	1358.70
3	1661.20	1296.50	1112.50	641.28	1216.90	1203.10
4	1599.00	1116.10	1029.60	883.30	474.26	998.23
5	851.81	1118.50	641.64	734.06	686.60	368.95
6	367.31	518.45	485.68	378.34	567.82	501.49
7	116.64	246.62	205.85	212.15	267.56	310.76
8	51.08	55.93	125.33	82.67	113.57	133.75
9	79.19	6.39	29.32	65.34	39.32	44.55
10	24.00	6.33	0.03	15.47	0.04	22.11

age \ year	2000	2001	2002	2003	2004	2005
1	1145.00	1264.70	1790.40	2429.40	2250.60	1910.60
2	1105.40	943.55	1045.80	1480.50	2006.70	1859.50
3	1123.60	814.79	754.73	792.13	1205.70	1647.40
4	932.03	840.47	635.59	488.70	624.52	963.71
5	722.63	651.31	575.50	425.16	378.46	474.41
6	236.53	500.46	316.39	358.83	302.97	257.61
7	248.99	124.69	123.64	180.13	227.30	183.98
8	125.55	27.79	9.79	44.43	70.44	135.22
9	87.75	3.90	3.08	3.33	22.38	33.79
10	26.17	11.46	3.66	1.98	0.04	10.78

age \ year	2006	2007	2008	2009	2010
1	1345.10	757.53	246.45	263.89	1353.80
2	1578.60	1098.10	612.39	199.38	218.22
3	1492.80	1236.70	827.50	443.22	130.38
4	1274.60	1107.80	836.84	593.43	263.30
5	669.03	768.41	496.88	490.83	362.80
6	293.33	345.07	388.93	247.61	293.58
7	140.08	124.74	173.03	218.83	127.84
8	53.86	28.92	50.18	58.17	62.61
9	43.62	30.10	13.78	11.64	23.84
10	0.00	3.19	6.02	0.03	5.80

units: NA

Slot "stock.wt":
An object of class "FLQuant", unit = unique, season = all, area = unique

age \ year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614
2	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083
3	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646
4	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292
5	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004
6	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731
7	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456
8	5.170	5.170	5.170	5.170	5.170	5.170	5.170	5.170	5.170	5.170
9	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876
10	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458

age \ year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.614	0.500
2	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.083	1.000
3	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.646	1.400
4	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	2.292	1.800
5	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	3.004	2.200
6	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.731	3.300
7	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.456	4.000
8	5.170	5.170	5.170	5.170	5.170	5.170	5.170	5.170	5.170	5.300
9	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876	5.876	6.600
10	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	7.458	12.117

age \ year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	0.457	0.383	0.727	0.453	0.600	0.090	0.614	0.614	0.614	0.614
2	0.730	0.777	0.947	0.893	0.760	0.720	1.083	1.083	1.083	1.083
3	1.247	1.153	1.427	1.100	1.070	0.953	1.000	1.000	1.300	1.300
4	1.777	1.710	1.997	1.543	1.593	1.570	1.600	1.600	1.700	1.700
5	2.160	2.120	2.647	2.087	2.083	2.220	2.100	2.100	2.200	2.200
6	3.243	3.030	3.907	2.963	2.597	2.993	2.800	2.800	3.100	3.100
7	3.900	4.257	5.283	4.443	4.200	4.423	4.300	4.300	4.300	4.300
8	5.447	5.467	6.300	5.820	5.900	6.000	6.000	6.000	6.000	6.000
9	6.500	6.600	8.800	8.340	8.300	8.500	9.500	9.500	7.000	7.000
10	12.278	12.352	9.537	9.369	9.473	9.500	7.458	10.500	10.314	9.500

age \ year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0.180	0.614	0.614	0.614	0.486	0.160	0.621	0.291	0.213	0.365
2	1.083	1.083	0.852	0.793	0.973	0.843	0.999	0.794	0.571	0.660
3	1.227	1.300	1.283	1.292	1.429	1.321	1.507	1.400	1.356	1.155
4	1.567	1.700	1.938	1.975	1.953	1.938	2.114	1.891	1.791	1.749
5	2.223	2.300	2.532	2.400	2.517	2.545	2.680	2.441	2.420	2.423
6	2.870	3.100	3.197	3.116	3.183	3.436	3.501	3.119	3.001	3.415
7	3.913	4.100	4.117	4.078	4.238	4.388	4.467	4.706	4.015	4.197
8	5.233	5.700	5.400	5.400	5.796	5.780	5.828	6.060	4.694	5.192
9	6.620	9.500	6.600	6.600	6.800	7.500	7.400	7.500	5.697	6.323
10	8.321	12.667	10.250	10.000	7.458	9.842	0.000	9.000	6.643	7.109

age \ year	2010
1	0.350
2	0.683
3	1.188
4	1.726

```
  5   2.511
  6   2.622
  7   3.846
  8   5.177
  9   5.999
  10  7.575

units:  NA

Slot "m":
An object of class "FLQuant", unit = unique, season = all, area = unique

    year
age  1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984
  1  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  2  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  3  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  4  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  5  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  6  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  7  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  8  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  9  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  10 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
    year
age  1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999
  1  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  2  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  3  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  4  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  5  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  6  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  7  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  8  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  9  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  10 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
    year
age  2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  1  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  2  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  3  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  4  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  5  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  6  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  7  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  8  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  9  0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19
  10 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19

units:  NA

Slot "mat":
An object of class "FLQuant", unit = unique, season = all, area = unique

    year
age  1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984
  1  0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
  2  0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
  3  0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75
  4  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  5  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  6  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  7  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  8  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  9  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  10 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
    year
age  1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999
  1  0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
  2  0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
  3  0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75
  4  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  5  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  6  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  7  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  8  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  9  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  10 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
    year
age  2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  1  0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
  2  0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
  3  0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75 0.75
  4  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  5  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  6  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  7  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  8  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  9  1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  10 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00

units:  NA

Slot "harvest":
An object of class "FLQuant", unit = unique, season = all, area = unique
```

age \ year	1970	1971	1972	1973	1974
1	0.00	0.00	0.00	0.00	0.00
2	0.03	0.00	0.00	0.00	0.00
3	0.17	0.03	0.07	0.03	0.00
4	0.13	0.30	0.04	0.08	0.01
5	0.47	0.22	0.24	0.32	0.08

```
     6          0.52       0.29       0.41       0.50       0.20
     7          0.78       0.47       0.52       0.98       0.46
     8          0.76       0.29       0.50       0.46       0.48
     9          0.54       0.32       0.35       0.47       0.25
    10          0.54       0.32       0.35       0.47       0.25
      year
age             1976       1977       1978       1979       1980
     1          0.00       0.00       0.00       0.00       0.00
     2          0.01       0.01       0.01       0.00       0.01
     3          0.03       0.02       0.03       0.08       0.06
     4          0.02       0.01       0.03       0.07       0.03
     5          0.12       0.06       0.12       0.33       0.15
     6          0.16       0.17       0.13       0.32       0.26
     7          0.22       0.25       0.24       0.38       0.23
     8          0.07       0.16       0.11       0.31       0.12
     9          0.12       0.13       0.13       0.28       0.16
    10          0.12       0.13       0.13       0.28       0.16
      year
age             1982       1983       1984       1985       1986
     1          0.00       0.00       0.00       0.00       0.00
     2          0.00       0.00       0.00       0.00       0.00
     3          0.25       0.33       0.17       0.00       0.00
     4          0.09       0.32       0.18       0.01       0.00
     5          0.32       0.88       0.28       0.02       0.03
     6          0.23       0.61       0.48       0.08       0.04
     7          0.42       0.41       0.58       0.18       0.16
     8          0.32       0.32       0.27       0.09       0.00
     9          0.28       0.51       0.36       0.08       0.05
    10          0.28       0.51       0.36       0.08       0.05
      year
age             1988       1989       1990       1991       1992
     1          0.00       0.00       0.01       0.02       0.01
     2          0.00       0.02       0.05       0.04       0.02
     3          0.00       0.08       0.16       0.16       0.02
     4          0.00       0.09       0.40       0.30       0.05
     5          0.11       0.20       0.31       0.41       0.09
     6          0.27       0.56       0.18       0.25       0.15
     7          0.31       0.46       0.51       0.27       0.12
     8          0.50       0.30       0.55       0.26       0.11
     9          0.24       0.32       0.39       0.30       0.10
    10          0.24       0.32       0.39       0.30       0.10
      year
age             1994       1995       1996       1997       1998
     1          0.00       0.02       0.05       0.00       0.00
     2          0.08       0.05       0.05       0.00       0.00
     3          0.21       0.04       0.04       0.11       0.01
     4          0.17       0.36       0.15       0.06       0.06
     5          0.31       0.64       0.34       0.07       0.12
     6          0.21       0.73       0.64       0.16       0.41
     7          0.54       0.49       0.72       0.43       0.50
     8          1.89       0.46       0.46       0.55       0.75
     9          0.63       0.54       0.46       0.26       0.37
    10          0.63       0.54       0.46       0.26       0.37
      year
age             2000       2001       2002       2003       2004
     1          0.00       0.00       0.00       0.00       0.00
     2          0.11       0.03       0.09       0.02       0.01
     3          0.10       0.06       0.24       0.05       0.03
     4          0.17       0.19       0.21       0.07       0.08
     5          0.18       0.53       0.28       0.15       0.19
     6          0.45       1.21       0.37       0.27       0.31
     7          2.00       2.35       0.83       0.75       0.33
     8          3.28       2.01       0.89       0.50       0.54
     9          1.23       1.27       0.52       0.35       0.29
    10          1.23       1.27       0.52       0.35       0.29
      year
age             2006       2007       2008       2009       2010
     1          0.01       0.02       0.02       0.00       0.01
     2          0.05       0.09       0.13       0.23       0.04
     3          0.11       0.20       0.14       0.33       0.21
     4          0.32       0.61       0.34       0.30       0.40
     5          0.47       0.49       0.51       0.32       0.55
     6          0.67       0.50       0.39       0.47       0.57
     7          1.39       0.72       0.90       1.06       0.82
     8          0.39       0.55       1.27       0.70       0.76
     9          0.71       0.67       0.59       0.45       0.63
    10          0.71       0.67       0.59       0.45       0.63

units:  f

Slot "harvest.spwn":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

    year
age  1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984
```

```
  1 0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  2 0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  3 0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  4 0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  5 0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  6 0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  7 0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  8 0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  9 0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  10 0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
    year
age  1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999
  1  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  2  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  3  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  4  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  6  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  7  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  8  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  9  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  10 0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
    year
age  2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  1  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  2  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  3  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  4  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  6  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  7  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  8  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  9  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5
  10 0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5  0.5

units:  NA

Slot "m.spwn":
An object of class "FLQuant", unit = unique, season = all, area = unique

    year
age  1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984
  1  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  2  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  3  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  4  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  5  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  6  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  7  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  8  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  9  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  10 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
    year
age  1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999
  1  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  2  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  3  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  4  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  5  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  6  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  7  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  8  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  9  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  10 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
    year
age  2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  1  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  2  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  3  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  4  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  5  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  6  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  7  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  8  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  9  0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  10 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25

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Years	SSB	Fbar	Rec	Catch	Landings
1970	13254.949	0.532	1715.084	5273.389	5273
1971	12324.734	0.314	2130.166	3051.594	3052
1972	11985.601	0.344	2091.576	3049.395	3049
1973	10973.399	0.467	3284.127	3704.586	3705
1974	11591.447	0.245	4005.719	1696.389	1696
1975	12668.565	0.137	3538.690	1272.895	1273
1976	17561.861	0.118	2952.646	1583.493	1584
1977	22137.939	0.130	3056.379	2011.684	2012
1978	21186.317	0.126	2024.831	2159.697	2160
1979	21724.833	0.283	1831.614	5447.177	5447
1980	19877.525	0.156	930.647	2842.780	2843
1981	19886.572	0.186	933.575	3275.479	3276

1982	17597.963	0.278	647.475	4662.362	4662
1983	10763.876	0.510	460.556	5306.468	5307
1984	8658.275	0.356	519.995	2851.763	2852
1985	7878.274	0.077	774.656	526.896	527
1986	10493.662	0.046	913.736	428.388	428
1987	6174.008	0.164	682.822	849.388	849
1988	6129.651	0.240	775.547	1115.583	1116
1989	5392.961	0.321	1429.920	1451.890	1452
1990	4135.209	0.391	2277.241	1409.687	1392
1991	3330.056	0.298	3532.995	952.185	935
1992	5394.821	0.102	3028.235	438.047	438
1993	6317.795	0.173	2279.790	1600.747	1601
1994	6734.921	0.623	1716.309	2138.882	2139
1995	6153.963	0.537	1008.970	2923.883	2924
1996	5634.132	0.462	1863.090	2006.100	2031
1997	5812.130	0.255	1759.067	1014.010	1014
1998	6110.609	0.369	1642.695	1574.115	1574
1999	6412.431	0.369	1336.359	1933.011	1933
2000	5010.806	1.216	1144.804	2692.705	2776
2001	4175.786	1.258	1264.326	2519.314	2522
2002	4069.850	0.518	1789.392	1397.505	1412
2003	4134.013	0.345	2429.212	931.456	943
2004	5137.153	0.293	2250.578	979.790	989
2005	6005.579	0.573	1905.919	2030.116	2039
2006	6527.603	0.647	1328.148	2694.770	2737
2007	5474.582	0.576	735.729	2734.715	2692
2008	4366.373	0.683	289.438	1923.493	1901
2009	3501.185	0.575	263.785	1699.474	1541
2010	2298.202	0.629	1393.429	1312.063	1321

7.2.5 Short term prediction of stock biomass and catch

Given the uncertainties of actual catches the STECF EWG 11 16 Black Sea did not undertake short term projections.

7.2.6 Medium term prediction of stock biomass and catch

Given the uncertainties of actual catches the STECF EWG 11 16 Black Sea did not undertake medium term projections.

7.2.7 Long term predictions Method 1: Yield per Recruit

7.2.7.1 Input parameters

Input parameters for YPR are derived from long term means of the XSA input data and averaged for the last 3 years with IUU catch included.

7.2.7.2 Results

Fmax was estimated as 0.342 from YpR curves based on exploitation paterns from the XSA assessment with IUU catch included (Fig. 6.2.7.2.1). $F_{0.1}$ were estimated at 0.18 (Table 6.2.7.2.1).

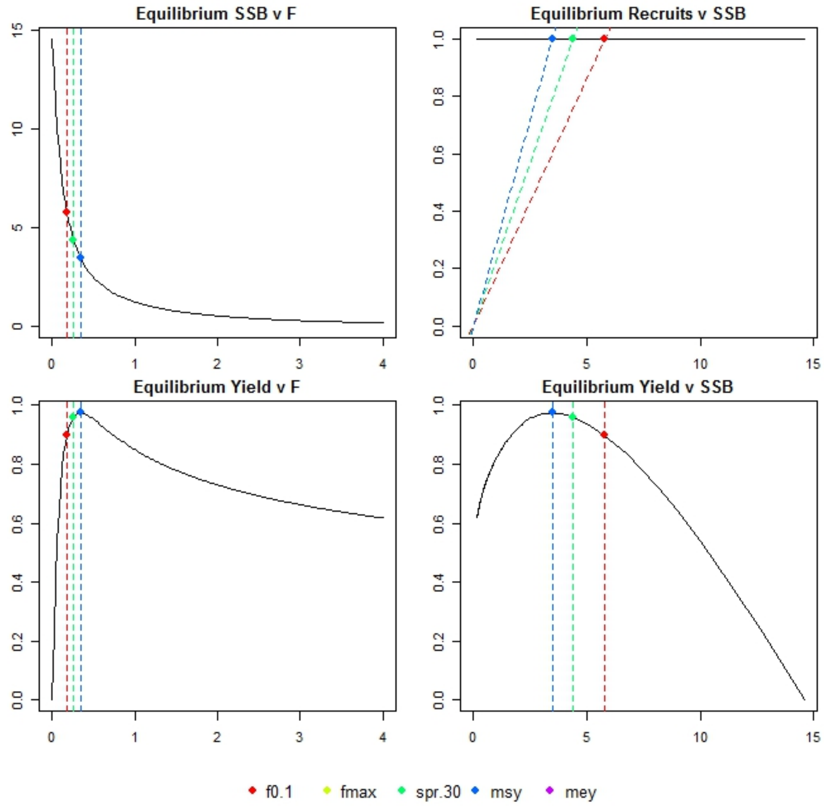

Fig. 6.2.7.2.1 Turbot in the Black Sea. SSBvR, RvSSB, YvF and Yv SSB from landings with IUU catch included (average of ages 4-8 y). Fmax= 0.342.

Table 6.2.7.2.1. Turbot in the Black Sea. Reference points based on equilibrium models with inputs of official landings with IUU estimates included.

	Harvest	Yield	Rec	SSB	Biomass	revenue	cost	profit
$f_{0.1}$	0.17844	0.89752	1	5.79186	6.76672	NA	NA	NA
f_{max}	0.3422	0.97406	1	3.47528	4.42888	NA	NA	NA
spr.30	0.25992	0.96068	1	4.3754	5.33956	NA	NA	NA
msy	0.3422	0.97406	1	3.47528	4.42888	NA	NA	NA
mey	NA	NA	NA	NA	NA	NA	NA	NA

7.2.8 Data quality

The available data from both fisheries dependent and fisheries independent sources is considered good enough in order to perform a reliable assessment of the stock. However, the lack of data for previous years and the unknown share of unreported landings make the analysis very sensitive to different options.

Landings from 2010 by age and size groups were not submitted by the Bulgarian authorities.

7.2.9 Scientific advice

7.2.9.1 Short term considerations

State of the spawning stock size: Uncertainties regarding the actual landings constrains STECF EWG 11-16 Black Sea to interpret the XSA assessment results only in relative terms, i.e. they are considered indicative of trends only. In the absence of precautionary reference points the EWG is unable to fully evaluate the stock size. However, survey indices and the XSA analyses inidicate that the stock size is at a historic low.

State of recruitment: Recruitment has increased since 2003 but this has not yet materialized in a significant increase in SSB.

State of exploitation: The STECF EWG 11-16 has proposed Fmsy=0.18 as limit reference point consistent with high long term yiels. Both assessment approaches, with and without estimated illegal catches, result in recent high F in the range of 0.6-0.8. The EWG classifies the stock of turbot in the Black Sea as being subject to overfishing. The EWG notes that despite the recently low TACs the fishing mortality remains at a level with no signal of reduction.

7.3 Anchovy in the Black Sea

7.3.1 Biological features

7.3.1.1 Stock Identification

European achovy *Engraulis encrasicolus* populations has been represented by two stocks in the Black Sea: the Black Sea and the Azov Sea stocks (Ivanov and Beverton 1985). The later reproduces and feeds in the Azov Sea and hibernates along the northern Caucasian and Crimean coast of the Black Sea.

The Black Sea stock has higher ecological and commercial importance and the information bellow concerns only this stock which will be further called Black sea anchovy.

Black sea anchovy is distributed in the whole Black Sea – Fig. 6.3.1.1.1. In October-November it migrates to the wintering grounds along the Anatolian and Caucasian coasts in southern Black Sea. In these areas it forms dense wintering concentrations in November-March which are subject to intensive commercial fishery. In the rest of the year it occupies its usual spawning and feeding habitats across the sea with some preference to the shelf areas and the northwestern part of the sea– characterized by the largest shelf area and high productivity due to abundant river run-off (Faschuk *et al*. 1995, Daskalov, 1999). But according to the studies carried out in the southern Black Sea (Turkey's EEZ) anchovy has also spawn in that area (Figure 2)(Niermann et al. 1994). It also may be affected from the climatic changes and other ecological impacts in the last 3 decades (Erdogan et al., 2008, 2010, Kasapoglu et al, 2010).

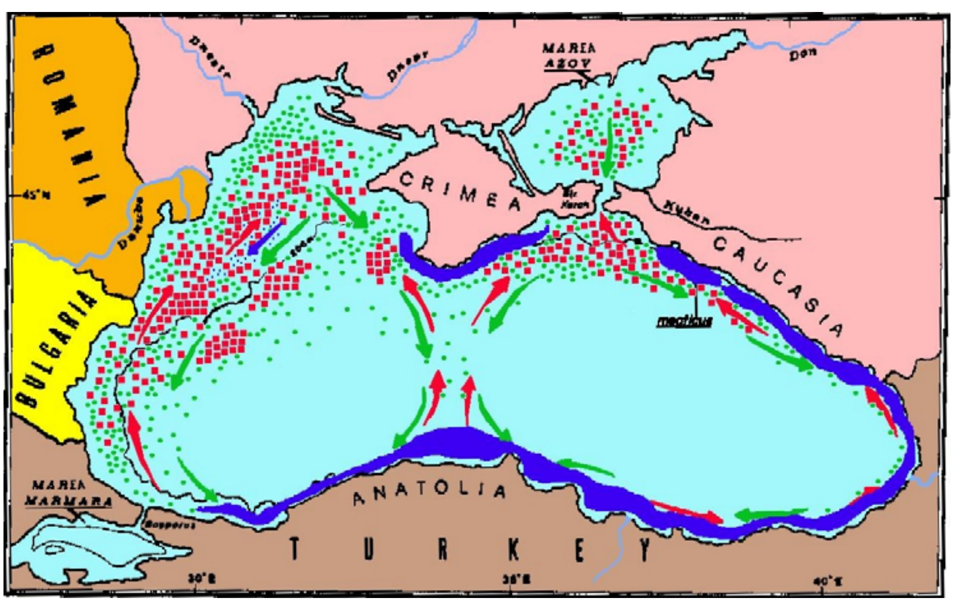

Fig. 6.3.1.1.1. Distribution of the anchovy at the Romanian littoral and in the whole Black Sea (Ivanov and Beverton 1985).

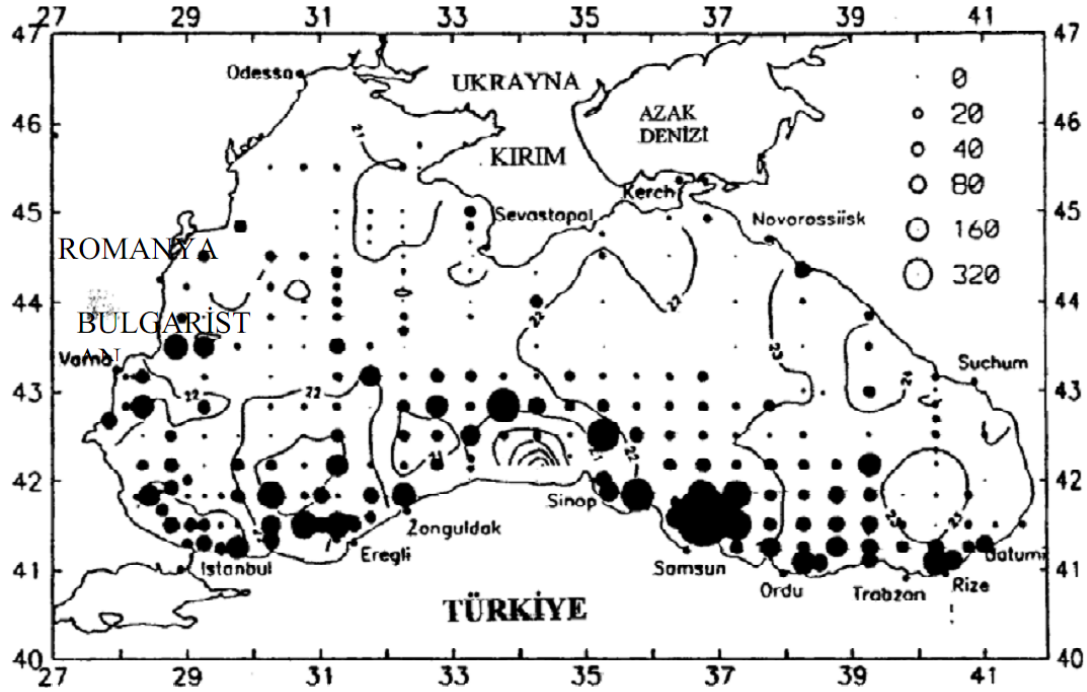

Fig. 6.3.1.1.2. Egg distribution of anchovy during 1991-1992 (Niermann et al. 1994).

7.3.1.2 Growth and mortality

During the last 10 year, the ages in the catch have been represented as 0 to 4, which older ages were observed not in the wintering areas.

At the first stage data must be carefully screened and organised into age structured matrices. Age structured assessment methods such as ICA and VPA (XSA) than can be applied similar to sprat.

l_{inf}	14.99
t0 =	:-1.85
K	: 0.459

In the last years, the anchovy individuals presented a total length which ranged between 106.14 mm and 115.88mm and the average weight of 6.79 -9.56g. The age of individuals oscillated between 0;0^+ - 3;3^+, dominant being the groups 1; 1^+ - 2; 2^+, as a consequence of the high fishing pressure in the wintering area (Maximov et. al, 2008).

The anchovy individuals presented a total length ranged from 5.5 to 14.9 cm in the samples but the average length is 11.14 cm in 2010 6.3.1.1.3).

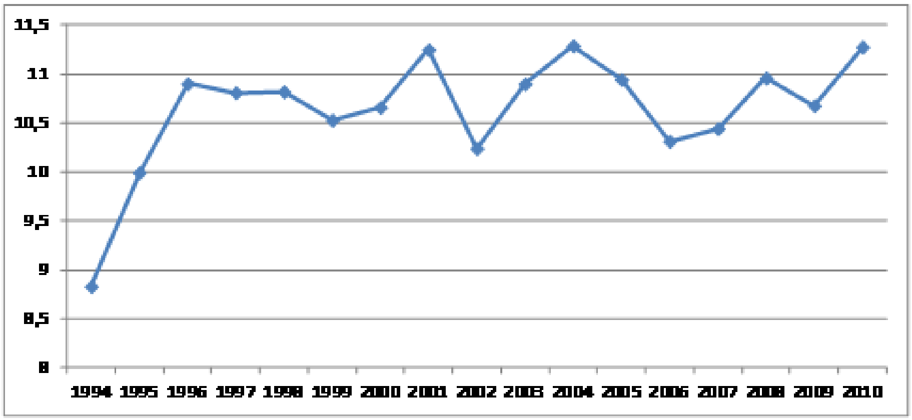

Fig.6.3.1.1.3. Mean annual length (cm) variation according to the landings (derived from Turkish data).

Weight of anchovy in the Turkish catch changes between 0.93 to 19.67 g and mean weight is 8.93 g in 2010 (Figure 6.3.1.1.4.).

Mean lengths in the catch is higher in the other areas. For instance size range in Bulgarian waters reported as 10.3-15.7 cm (mean 12.13 cm) and 8.26-24.5 g (mean 12.85 g) (Yankova et al.,2011).

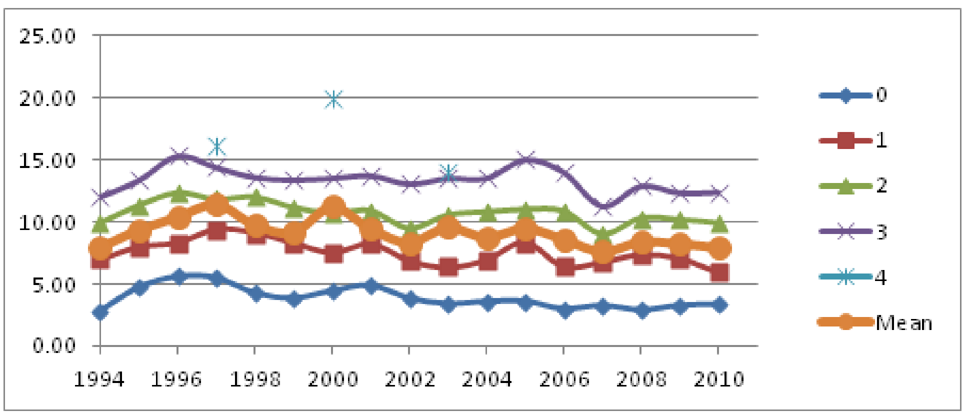

Figure 6.3.1.1.4. Average mean weights of anchovy in the catch in the Black Sea

These two figures on length and weight variation by years show that average size values increased after 1994 and stabilized more around 11 cm and 8 g(Ozdamar et al., 199; Duzgunes et al. 1995, Genc et al. 1999, Gozler and Ciloglu,1998, Kayalı, 1998, 1995; Mutlu, 2000; Samsun et al. 2004,2006; Bilgin et al, 2006; Sahin et al., 2006; Genc et al;, 2010).

Table 6.3.1.2.1 VBGF parameters calculated in the Black Sea

	L_∞	**K**	**t_0**	**a**	**b**
Bulgaria	16.62	0.278	-2.666	0.006045	2.972
Romania	15.55	0.360	-1.396	0.005754	3.0256
Ukraine	**13.90**	**0.985**	**-0.74**		
Turkey	14.99	0.459	-1.85	0.0058	3.018

MORTALITY (2010)

	Z	F	M
Bulgaria			
Romania	0.530[1] 0.693[2]	 0.164	0.529[3]
Ukraine			**0.84**
Turkey	2.411[2]	1.79	0.803[4]

[1]Beverton&Holt, [2]Age-lengthfrequency, [3]Richter and Ivanov, [4] Pauly (using mean annual water temperature as 16 dC), various methods according to Mikhailov and Prodanov 1983

Natural mortality (M) is probably the most important parameter in models of population dynamics, especially in short lived species, and is the one proved to be the most difficult to estimate. In nature natural mortality may vary among years and ages/sizes. We would expect M to be higher and a subject of large variability in the Black Sea, because of the relatively small size of the Black Sea fishes (compared to the same species in the Atlantic Ocean) that make them highly vulnerable to predation and other natural impacts. In this study we used an average M of 0.62 transformed into variable M by ages (Caddy and Abella, 1999). Sensitity studies have shown that VPA results are mainly sensitive to the mean M and in a less degree to the particular shape of the M at age vector (Daskalov 1999).

7.3.1.3 Maturity

First maturity age is year 1 for anchovy. It spawns during the summer, which is also the main feeding and growth season. The main feature characterizing the summer habitat is the strong stratification of the water due to the seasonal thermocline and reinforced in coastal and shelf waters by the river plumes. Anchovy was found to spawn mainly in the surface layer of these warm and stratified areas (Arkhipov, 1993; Fashchuk *et al.* 1995). Eggs and larvae are retained in the coastal layer stabilized in depth by the thermocline and protected from the offshore by thermo-haline fronts. A large convergence zone is formed on the northwestern and the western shelf (the main anchovy spawning area) due to the river Danube inflow, which favors fish offspring retention (Radu and Maximov 2006-2008).

7.3.2 Fisheries

7.3.2.1 General description

Anchovy is an object of both artisanal (with coastal trap nets and beach seines), and commercial purse-seines fishery on the wintering grounds. Majority of the production has obtained by Turkey by purse seine vessels.

The catch of the Black Sea countries increased until 1985-1986 after which a sharp decline occurred. For instance, the Turkish catch of anchovy in 1990-1991 fell to 13-15% of the 1985-1986 level.

Heavy fishing on small pelagic fish predominantly by the Soviet Union, and later also by Turkey, was carried out in a competitive framework without any agreement between the countries on limits to fishing. Depletion of the small pelagic stock appears to have led to increased opportunities for population explosion of planktonic predators (jelly fish and ctenophores) which have competed for food with fish, and preyed on their eggs and larvae.

The total anchovy catch was progressively increasing since 1980 to 1988 when maximum yield was obtained (606,401t) then decreasing up to a minimum of 102,904 t in 1990 (excepting 1988), 90% from this quantity being obtained by Turkey.

In spite of improving the fishing effort by the continuous increase of fishing vessels number, at the end of the 1980's when the outbreak of the alien jellyfish occurred, catches dramatically declined up to three times.

The state of the anchovy stock has improved after the collapse in 1990s, and in 2000-2005 the catches reached levels of about 300 th. tons.

However in 2006 the anchovy catches dropped to 119 thousand t in Turkey (TUIK, 2007) showing that the stock is not in a good condition. This year, bonito catches reached the maximum amount of the last 50 years (63896 tons) and most of the purse seiners preferred to catch bonito considering the high market value of that fish. On the other hand, the possible causes of the drop ranges may be attributed to the climate effects (raised water temperature may cause a dispersal of fish schools making them less accessible to the fishing gears), abundant predators (bonito) or overfishing. In 2006 the catch increased again to 212 thousand t.

In 2010, total Black Sea catch has reached to 208192 tons and the major part is harvested by Turkey as 203026 tons (Table 6.3.2.1.1).

Table 6.3.2.1.1 Anchovy landings in the Black Sea (t)

YEAR	BULGARIA	GEORGIA	ROMANIA	RUSSIAN FEDERATION	TURKEY	UKRAINE	TOTAL
1994		857	197	0	293167	4797	299018
1995	35	1301	190	11	389298	10260	401095
1996	23	1232	140	4	276137	3092	280628
1997	44	2288	45	11	221475	3328	227191
1998	48	2346	146		199363	2611	204514
1999	36	1264	155		315989	2423	319867
2000	64	1487	204		272390	5496	279641
2001	102	941	186		300569	7952	309750
2002	237	927	296		346869	9567	357896
2003	131	2665	160		278238	8159	289353
2004	88	2562	135		312603	7458	322846
2005	14	2600	154		125635	6860	135263
2006	6	9222	23		219171	3936	232358
2007	60	17447	87		361662	4935	384191
2008	28	25938	15		229632	9515	265128
2009	42		21		193630	9948	203641
2010	65		50		203026	5051	208192

7.3.2.2 Management regulations applicable in 2010 and 2011

The lack of an adequate management in the Black Sea fisheries is also underlined by the fact that in spite of the obvious decline of stocks, the fishing effort continued to increase not only by the numbers of vessels but also the increased efficiency of fish finders, fishing nets and gears, modernization of the vessels and navigation instruments.

In the Black Sea countries, anchovy fishing are generally regulated by using closed seasons (May April to October to October/November for Bulgaria and Romania, April to October/November for Turkey, and no closed season for Ukraina), closed areas, mesh size regulations, minimum landing size (9 cm total length in general).

7.3.2.3 Catches

7.3.2.3.1 Landings

Table 6.3.2.3.1.1.Anchovy landings by countries (in tons, FAO Fisheries Statistics, GFCM Capture Production 1970 – 2006, 2007 – 2009 from National Fisheries Statistics of countries).

Year	Bulgaria	Georgia	Romania	Russian Federation	Turkey*	Ukraine	Un. Sov. Soc. Rep.
1970	90	.	2261	.	71506	.	117800
1971	126	.	3791	.	70400	.	126700
1972	156	.	3200	.	91675	.	111000
1973	264	.	1400	.	86998	.	132500
1974	41	.	855	.	75728	.	227900
1975	15	.	592	.	59142	.	173626
1976	72	.	2749	.	67992	.	236234
1977	113	.	1646	.	71366	.	152607
1978	37	.	2746	.	105184	.	134855
1979	307	.	2251	.	133678	.	126763
1980	209	.	6431	.	239289	.	165900
1981	70	.	4942	.	259767	.	153272
1982	266	.	4294	.	266523	.	175100
1983	784	.	5532	.	289860	.	200630
1984	239	.	6354	.	318917	.	240640
1985	92	.	2414	.	273274	.	110200
1986	96	.	2510	.	274740	.	191370
1987	13	.	1447	.	295902	.	66241
1988	115	97452	3171	64852	295000	65872	-
1989	.	32401	61	16426	96806	15536	-
1990	.	4656	5	6780	66409	17392	-
1991	.	5643	46	42	79225	1796	-
1992	.	6871	85	7294	155417	11507	-
1993	.	1656	374	2137	218866	8698	-
1994	.	857	197	4600	278667	14500	-
1995	35	1301	189	10071	373782	15516	-
1996	23	1232	138	2954	273239	2898	-
1997	44	2288	45	3283	213780	7695	-
1998	48	2346	146	2465	195996	3367	-
1999	36	1264	155	2268	310801	5188	-
2000	64	1487	204	5292	260670	11720	-
2001	102	941	186	7766	288616	11953	-
2002	237	927	296	9271	336419	10450	-
2003	131	2665	160	7999	266069	12169	-
2004	88	2562	135	7323	306656	5947	-
2005	14	2600	154	6706	119255	6380	-
2006	7	9222	11	3925	212081	7090	-
2007	60	17447	35	4900	357089	4573	
2008	28	25938	15	9500	225334	4298	
2009	42		21	9927	185606	8024	
2010	65		50		203026	5051	

*includes Sea of Marmara and Aegean Sea catches till 2007

7.3.2.3.2 Discards

Discards of Anchovy appear neglibible. Although no discards have been reported, some untargeted fish as dogfish, rays, turbot, marine mammals, small sized anchovies and blue fish have been caught due to use of purse seine nets, which has no selectivity, in shallow waters in the coasts of Turkey and Georgia.

7.3.2.4 Fishing effort and CPUE

There is no data available on CPUE in the Black Sea mainly in Turkey. According to the surveys carried out in Romania, it is reported that mean CPUE values are 2437.3 kg per gears, 33.479 kg per soaking days and 36.296 kg per fishing days which derived using the pound net catch data.

For stock assessment purposes effective effort for specific fishing methods is needed. In case of Turkey, FIS is progressing and according to the landing and effort as total HP (calculated by the number and the mean HP of the purse seiners) short term time series had been derived as follows;

Years	Total HP	Age group			
		0	1	2	3
2006	273658	52214,68	193354,66	77689,69	5650,79
2007	302431	62200,86	370359,12	112516,00	6287,97
2008	361894	16630,05	152713,61	131042,20	7924,34
2009	308825	28011,34	151653,51	84112,26	7572,47
2010	261510	14615,17	93698,39	133919,40	11922,00

7.3.3 Scientific Surveys

No surveys covering the major stock distribution area exist.

7.3.4 Assessment of historic parameters

7.3.4.1 Method 1: XSA

7.3.4.1.1 Jusification

STECF SG Black Sea-10-01 found out that data available in different national databases would allow performing a quantitative assessment of this stock. This however would be less straightforward than previous assessment of sprat because of the specific seasonal and migration behaviour of anchovy: 95% of the catch is taken in Turkish waters (southern Black Sea) in the autumn and winter. The important Turkish data can be complemented by biological (age and individual size and growth) and survey information (acoustics, juveniles, egg-production) from Bulgaria, Romania and Ukraine.

An XSA was formultated tuned with the CPUE at age derived from the Turkish commercial purse seiner fishery.

7.3.4.1.2 Input parameters

Table 6.3.4.1.2.1. Data availability by countries.

Type of data	**BG**	**RO**	**UKR**	**TR**	**Selection for Assessment**	**Comments**
Official landings	1925-2008	1950-2008	1967 - 2009	1967 - 2010 (after 15th July)		
Illegal, Unreported Catch	no	no	no	No		
Fishing effort and CPUE	no	1980-2008	till 2009	1998, 2000-2008		* to be reviewed
Number of fishing vessels			till 2009	1993-2010		
Research surveys -adult			till 2009	1993-1998, 2000-2008		
Reserch surveys -juvenile		1995-2008	till 1992	No		
Hydroacoustic surveys	1984-87, 1990		1992, 1998-2003	1990-1993		
Length composition	1998-2000	1980-2008	till 2008	till 2010		
Weight at length (survey, landings)	1998-2000, *VII, VIII, IX, XI.1999	1980-2008	till 2009	till 2010		
Age composition	1995-2000, VII, VIII, IX, XI.1999	1980-2008	till 2009	till 2010		
Weight at age (survey, landings)	1995-2000	1980-2008	till 2009	till 2010		
Maturity at age (method by Caddy and Abella, 1999)		1980-2008	till 2008	0.62		
Natural mortality		1980-2008	till 1990	till 2010		

The expert working group used the spreadsheet model by Caddy and Abella (1999) to estimate the natural mortaliy vector based on life history traits.

Talbe 6.3.4.1.2.2 XSA input data.

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An object of class "FLQuant"
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  2 19046510 14100772  8186804  6084023  6539958  9306237 10780982  6869537
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  2 10852933
  3   894861
  4        2

units:  NA

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  1 0.00790 0.00719 0.00756 0.00904 0.00714 0.00790 0.00812 0.00806 0.00645
  2 0.01019 0.01098 0.01126 0.01116 0.01128 0.00971 0.01084 0.01070 0.01023
  3 0.01289 0.01357 0.01355 0.01488 0.01374 0.01166 0.01284 0.01242 0.01217
  4 0.01289 0.01357 0.01355 0.01488 0.01374 0.01166 0.01284 0.01242 0.01217

units:  NA

Slot "discards":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

     year
age   2002 2003 2004 2005 2006 2007 2008 2009 2010
  all 0    0    0    0    0    0    0    0    0

units:  NA

Slot "discards.n":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002 2003 2004 2005 2006 2007 2008 2009 2010
  0 0    0    0    0    0    0    0    0    0
  1 0    0    0    0    0    0    0    0    0
  2 0    0    0    0    0    0    0    0    0
  3 0    0    0    0    0    0    0    0    0
  4 0    0    0    0    0    0    0    0    0

units:  NA

Slot "discards.wt":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002 2003 2004 2005 2006 2007 2008 2009 2010
  0 0    0    0    0    0    0    0    0    0
  1 0    0    0    0    0    0    0    0    0
  2 0    0    0    0    0    0    0    0    0
  3 0    0    0    0    0    0    0    0    0
  4 0    0    0    0    0    0    0    0    0

units:  NA

Slot "landings":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

     year
age   2002   2003   2004   2005   2006   2007   2008   2009   2010
  all 357896 289353 322846 135263 232358 384191 265127 203641 208191

units:  NA

Slot "landings.n":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
```

```
age 2002     2003     2004     2005     2006     2007     2008     2009    
  0  4094839  2892147  1932066  2460138  6112615  7189643  2063498  3246771
  1 25045570 12134406 17449630  4764947 17951069 34399398 14011766 13795286
  2 19046510 14100772  8186804  6084023  6539958  9306237 10780982  6869537
  3  3472967  5171706  6905509  1497348   427350   472028   594815   568603
  4        2        2        2        2        2        2        2        2
   year
age 2010    
  0  2647859
  1  9683846
  2 10852933
  3   894861
  4        2

units:  NA 

Slot "landings.wt":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002    2003    2004    2005    2006    2007    2008    2009    2010   
  0 0.00505 0.00495 0.00499 0.00517 0.00458 0.00480 0.00452 0.00483 0.00572
  1 0.00790 0.00719 0.00756 0.00904 0.00714 0.00790 0.00812 0.00806 0.00645
  2 0.01019 0.01098 0.01126 0.01116 0.01128 0.00971 0.01084 0.01070 0.01023
  3 0.01289 0.01357 0.01355 0.01488 0.01374 0.01166 0.01284 0.01242 0.01217
  4 0.01289 0.01357 0.01355 0.01488 0.01374 0.01166 0.01284 0.01242 0.01217

units:  NA 

Slot "stock":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

     year
age   2002 2003 2004 2005 2006 2007 2008 2009 2010
  all 0    0    0    0    0    0    0    0    0   

units:  NA * NA 

Slot "stock.n":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002       2003       2004       2005       2006       2007      
  0 2.0793e+08 1.8210e+08 1.1480e+08 2.2556e+08 3.5157e+08 3.1199e+08
  1 1.3345e+08 5.3430e+07 4.7150e+07 2.9669e+07 5.8983e+07 9.0758e+07
  2 5.4134e+07 4.2660e+07 1.5675e+07 9.3365e+06 1.0020e+07 1.4266e+07
  3 1.1408e+07 1.6527e+07 1.3710e+07 2.7665e+06 7.3491e+05 7.8095e+05
  4 6.3828e+00 6.2050e+00 3.7804e+00 3.4996e+00 3.2365e+00 3.1007e+00
   year
age 2008       2009       2010      
  0 2.3834e+08 2.4858e+08 2.3836e+08
  1 7.9628e+07 6.2601e+07 6.4726e+07
  2 1.7431e+07 2.6078e+07 1.8648e+07
  3 1.1154e+06 1.8086e+06 9.7038e+06
  4 3.5560e+00 6.1754e+00 2.1375e+01

units:  NA 

Slot "stock.wt":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002    2003    2004    2005    2006    2007    2008    2009    2010   
  0 0.00505 0.00495 0.00499 0.00517 0.00458 0.00480 0.00452 0.00483 0.00572
  1 0.00790 0.00719 0.00756 0.00904 0.00714 0.00790 0.00812 0.00806 0.00645
  2 0.01019 0.01098 0.01126 0.01116 0.01128 0.00971 0.01084 0.01070 0.01023
  3 0.01289 0.01357 0.01355 0.01488 0.01374 0.01166 0.01284 0.01242 0.01217
  4 0.01289 0.01357 0.01355 0.01488 0.01374 0.01166 0.01284 0.01242 0.01217

units:  NA 

Slot "m":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique
```

```
   year
age 2002 2003 2004 2005 2006 2007 2008 2009 2010
  0 1.32 1.32 1.32 1.32 1.32 1.32 1.32 1.32 1.32
  1 0.81 0.81 0.81 0.81 0.81 0.81 0.81 0.81 0.81
  2 0.56 0.56 0.56 0.56 0.56 0.56 0.56 0.56 0.56
  3 0.48 0.48 0.48 0.48 0.48 0.48 0.48 0.48 0.48
  4 0.48 0.48 0.48 0.48 0.48 0.48 0.48 0.48 0.48

units:  NA

Slot "mat":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002 2003 2004 2005 2006 2007 2008 2009 2010
  0 0    0    0    0    0    0    0    0    0
  1 1    1    1    1    1    1    1    1    1
  2 1    1    1    1    1    1    1    1    1
  3 1    1    1    1    1    1    1    1    1
  4 1    1    1    1    1    1    1    1    1

units:  NA

Slot "harvest":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002     2003     2004     2005     2006     2007     2008     2009
  0 0.038847 0.031211 0.033104 0.021328 0.034218 0.045611 0.016893 0.025596
  1 0.330442 0.416279 0.809397 0.275481 0.609364 0.839953 0.306289 0.401071
  2 0.626475 0.575094 1.174511 1.981938 1.991869 1.988679 1.705682 0.428553
  3 0.489380 0.507177 1.022443 1.164921 1.344104 1.462658 1.132993 0.510262
  4 0.489380 0.507177 1.022443 1.164921 1.344104 1.462658 1.132993 0.510262
   year
age 2010
  0 0.021727
  1 0.254007
  2 1.469962
  3 0.124692
  4 0.124692

units:  f

Slot "harvest.spwn":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002 2003 2004 2005 2006 2007 2008 2009 2010
  0 0    0    0    0    0    0    0    0    0
  1 0    0    0    0    0    0    0    0    0
  2 0    0    0    0    0    0    0    0    0
  3 0    0    0    0    0    0    0    0    0
  4 0    0    0    0    0    0    0    0    0

units:  NA

Slot "m.spwn":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002 2003 2004 2005 2006 2007 2008 2009 2010
  0 0    0    0    0    0    0    0    0    0
  1 0    0    0    0    0    0    0    0    0
  2 0    0    0    0    0    0    0    0    0
  3 0    0    0    0    0    0    0    0    0
  4 0    0    0    0    0    0    0    0    0

units:  NA

Slot "name":
[1] "BLACK SEA ANCHOVY Total,2010,COMBSEX,PLUSGROUP"

Slot "desc":
[1] "Imported from a VPA file. ( BSAn00IN_1_1.DAT ).  Thu Oct 13 15:56:37 2011 + FLAssess: "
```

```
Slot "range":
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         4         4      2002      2010         1         3
```

7.3.4.1.3 Diagnostics and results

Table 6.3.4.1.3.1 Tuning diagnostics

```
FLR XSA Diagnostics 2011-10-13 15:58:35

CPUE data from bsa.idx

Catch data for 9 years 2002 to 2010. Ages 0 to 4.

           fleet first age last age first year last year alpha beta
1 RO Trawl fleet         1        1       2006      2010  <NA> <NA>


 Time series weights :

    Tapered time weighting applied
   Power =   3 over  20 years

 Catchability analysis :

     Catchability independent of size for ages >   1

     Catchability independent of age for ages >   1

 Terminal population estimation :

     Survivor estimates shrunk towards the mean F
    of the final   5 years or the  2 oldest ages.

    S.E. of the mean to which the estimates are shrunk =   2

    Minimum standard error for population
    estimates derived from each fleet =  0.3

    prior weighting not applied

Regression weights
     year
age   2002  2003  2004  2005  2006 2007  2008 2009 2010
  all 0.82 0.877 0.921 0.954 0.976 0.99 0.997    1    1


 Fishing mortalities
   year
age  2002  2003  2004  2005  2006  2007  2008  2009  2010
  0 0.039 0.031 0.033 0.021 0.034 0.046 0.017 0.026 0.022
  1 0.330 0.416 0.809 0.275 0.609 0.840 0.306 0.401 0.254
  2 0.626 0.575 1.175 1.982 1.992 1.989 1.706 0.429 1.470
  3 0.489 0.507 1.022 1.165 1.344 1.463 1.133 0.510 0.125
  4 0.489 0.507 1.022 1.165 1.344 1.463 1.133 0.510 0.125


 XSA population number (Thousand)
      age
year          0         1        2        3  4
  2002 207934105 133446056 54134274 11408479  6
  2003 182097915  53430117 42659740 16526945  6
  2004 114801826  47149971 15675451 13710496  4
  2005 225557442  29669030  9336547  2766506  3
  2006 351573039  58982830 10020398   734914  3
  2007 311990518  90758257 14266041   780948  3
  2008 238335414  79627705 17430942  1115389  4
  2009 248579749  62601281 26077504  1808621  6
  2010 238361361  64726328 18647549  9703822 21


 Estimated population abundance at 1st Jan  2011
```

```
      age
year          0        1        2       3       4
  2011 62309061 62309061 22337276 2451587 5301577


 Fleet:  RO Trawl fleet

 Log catchability residuals.

   year
age   2006   2007  2008  2009  2010
  1 -0.107 -0.087 0.098 0.032 0.061

 Regression statistics
 Ages with q dependent on year class strength
[1] "0.773973113976388" "11.0933692365713"


 Terminal year survivor and F summaries:

 ,Age 0 Year class =2010

source
     scaledWts survivors yrcls
fshk     0.041  43577867  2010
nshk     0.959  63274115  2010

 ,Age 1 Year class =2009

source
               scaledWts survivors yrcls
RO Trawl fleet     0.972  24158631  2009
fshk               0.028   9716517  2009

 ,Age 2 Year class =2008

source
     scaledWts survivors yrcls
fshk         1   1862900  2008

 ,Age 3 Year class =2007

source
     scaledWts survivors yrcls
fshk         1    492872  2007
```

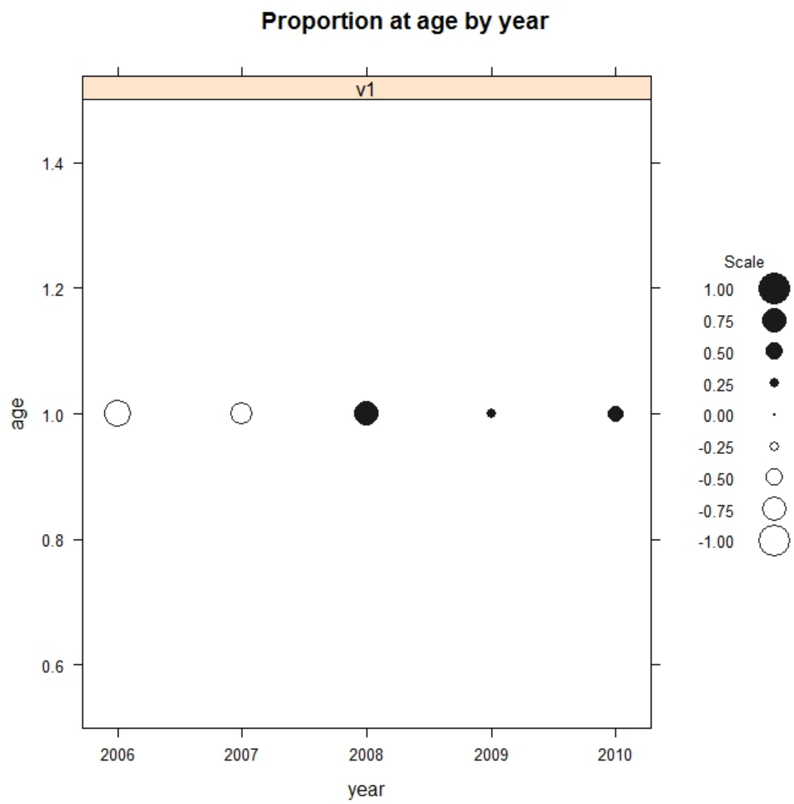


Fig. 6.3.4.1.3.1 Tuning results. Log transformed residuals of catchability.

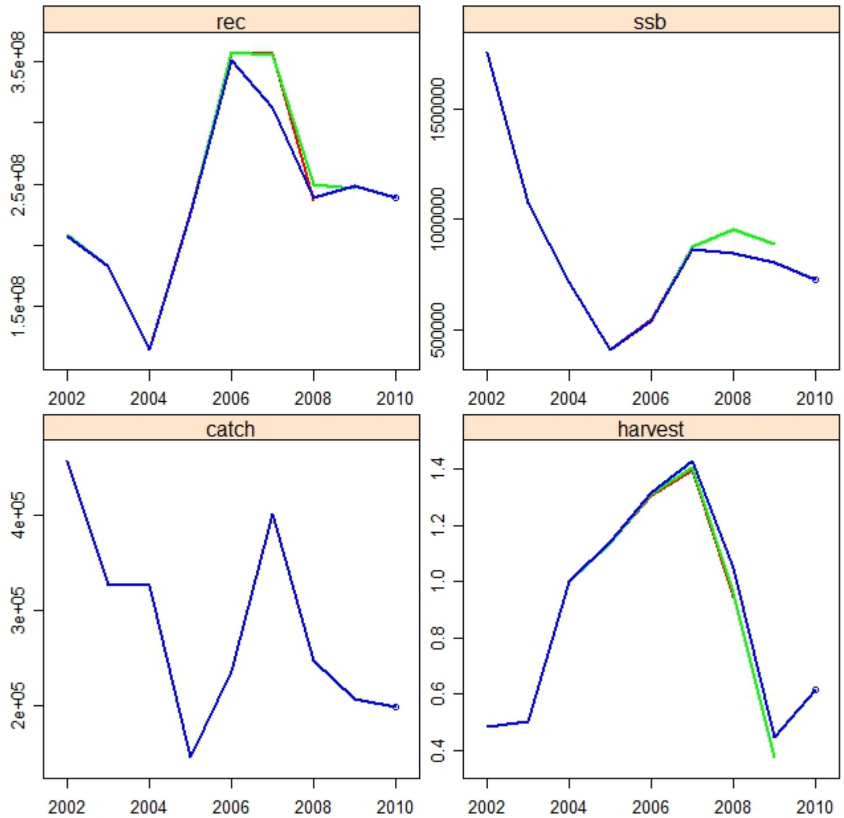


Fig. 6.3.4.1.3.2 Retrospective analysis of stock parameters.

Table 6.3.4.1.3.2 XSA results

```
An object of class "FLStock"
Slot "catch":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

     year
age   2002   2003   2004   2005   2006   2007   2008   2009   2010
  all 457389 326569 327313 145972 235809 402133 247606 207438 199523

units:  NA NA

Slot "catch.n":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002     2003     2004     2005     2006     2007     2008     2009
  0  4094839  2892147  1932066  2460138  6112615  7189643  2063498  3246771
  1 25045570 12134406 17449630  4764947 17951069 34399398 14011766 13795286
  2 19046510 14100772  8186804  6084023  6539958  9306237 10780982  6869537
  3  3472967  5171706  6905509  1497348   427350   472028   594815   568603
  4        2        2        2        2        2        2        2        2
   year
age 2010
  0  2647859
  1  9683846
  2 10852933
  3   894861
  4        2

units:  NA
```

```
Slot "catch.wt":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002    2003    2004    2005    2006    2007    2008    2009    2010
  0 0.00505 0.00495 0.00499 0.00517 0.00458 0.00480 0.00452 0.00483 0.00572
  1 0.00790 0.00719 0.00756 0.00904 0.00714 0.00790 0.00812 0.00806 0.00645
  2 0.01019 0.01098 0.01126 0.01116 0.01128 0.00971 0.01084 0.01070 0.01023
  3 0.01289 0.01357 0.01355 0.01488 0.01374 0.01166 0.01284 0.01242 0.01217
  4 0.01289 0.01357 0.01355 0.01488 0.01374 0.01166 0.01284 0.01242 0.01217

units:  NA

Slot "discards":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

     year
age   2002 2003 2004 2005 2006 2007 2008 2009 2010
  all 0    0    0    0    0    0    0    0    0

units:  NA

Slot "discards.n":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002 2003 2004 2005 2006 2007 2008 2009 2010
  0 0    0    0    0    0    0    0    0    0
  1 0    0    0    0    0    0    0    0    0
  2 0    0    0    0    0    0    0    0    0
  3 0    0    0    0    0    0    0    0    0
  4 0    0    0    0    0    0    0    0    0

units:  NA

Slot "discards.wt":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002 2003 2004 2005 2006 2007 2008 2009 2010
  0 0    0    0    0    0    0    0    0    0
  1 0    0    0    0    0    0    0    0    0
  2 0    0    0    0    0    0    0    0    0
  3 0    0    0    0    0    0    0    0    0
  4 0    0    0    0    0    0    0    0    0

units:  NA

Slot "landings":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

     year
age   2002   2003   2004   2005   2006   2007   2008   2009   2010
  all 357896 289353 322846 135263 232358 384191 265127 203641 208191

units:  NA

Slot "landings.n":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002     2003     2004     2005     2006     2007     2008     2009
  0  4094839  2892147  1932066  2460138  6112615  7189643  2063498  3246771
  1 25045570 12134406 17449630  4764947 17951069 34399398 14011766 13795286
  2 19046510 14100772  8186804  6084023  6539958  9306237 10780982  6869537
  3  3472967  5171706  6905509  1497348   427350   472028   594815   568603
  4        2        2        2        2        2        2        2        2
   year
age 2010
  0  2647859
  1  9683846
  2 10852933
  3   894861
```

```
  4       2

units:  NA

Slot "landings.wt":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002    2003    2004    2005    2006    2007    2008    2009    2010   
  0 0.00505 0.00495 0.00499 0.00517 0.00458 0.00480 0.00452 0.00483 0.00572
  1 0.00790 0.00719 0.00756 0.00904 0.00714 0.00790 0.00812 0.00806 0.00645
  2 0.01019 0.01098 0.01126 0.01116 0.01128 0.00971 0.01084 0.01070 0.01023
  3 0.01289 0.01357 0.01355 0.01488 0.01374 0.01166 0.01284 0.01242 0.01217
  4 0.01289 0.01357 0.01355 0.01488 0.01374 0.01166 0.01284 0.01242 0.01217

units:  NA

Slot "stock":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

     year
age   2002 2003 2004 2005 2006 2007 2008 2009 2010
  all 0    0    0    0    0    0    0    0    0   

units:  NA * NA

Slot "stock.n":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002       2003       2004       2005       2006       2007      
  0 2.0793e+08 1.8210e+08 1.1480e+08 2.2556e+08 3.5157e+08 3.1199e+08
  1 1.3345e+08 5.3430e+07 4.7150e+07 2.9669e+07 5.8983e+07 9.0758e+07
  2 5.4134e+07 4.2660e+07 1.5675e+07 9.3365e+06 1.0020e+07 1.4266e+07
  3 1.1408e+07 1.6527e+07 1.3710e+07 2.7665e+06 7.3491e+05 7.8095e+05
  4 6.3828e+00 6.2050e+00 3.7804e+00 3.4996e+00 3.2365e+00 3.1007e+00
   year
age 2008       2009       2010      
  0 2.3834e+08 2.4858e+08 2.3836e+08
  1 7.9628e+07 6.2601e+07 6.4726e+07
  2 1.7431e+07 2.6078e+07 1.8648e+07
  3 1.1154e+06 1.8086e+06 9.7038e+06
  4 3.5560e+00 6.1754e+00 2.1375e+01

units:  NA

Slot "stock.wt":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002    2003    2004    2005    2006    2007    2008    2009    2010   
  0 0.00505 0.00495 0.00499 0.00517 0.00458 0.00480 0.00452 0.00483 0.00572
  1 0.00790 0.00719 0.00756 0.00904 0.00714 0.00790 0.00812 0.00806 0.00645
  2 0.01019 0.01098 0.01126 0.01116 0.01128 0.00971 0.01084 0.01070 0.01023
  3 0.01289 0.01357 0.01355 0.01488 0.01374 0.01166 0.01284 0.01242 0.01217
  4 0.01289 0.01357 0.01355 0.01488 0.01374 0.01166 0.01284 0.01242 0.01217

units:  NA

Slot "m":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002 2003 2004 2005 2006 2007 2008 2009 2010
  0 1.32 1.32 1.32 1.32 1.32 1.32 1.32 1.32 1.32
  1 0.81 0.81 0.81 0.81 0.81 0.81 0.81 0.81 0.81
  2 0.56 0.56 0.56 0.56 0.56 0.56 0.56 0.56 0.56
  3 0.48 0.48 0.48 0.48 0.48 0.48 0.48 0.48 0.48
  4 0.48 0.48 0.48 0.48 0.48 0.48 0.48 0.48 0.48

units:  NA

Slot "mat":
An object of class "FLQuant"
```

```
, , unit = unique, season = all, area = unique

   year
age 2002 2003 2004 2005 2006 2007 2008 2009 2010
  0 0    0    0    0    0    0    0    0    0
  1 1    1    1    1    1    1    1    1    1
  2 1    1    1    1    1    1    1    1    1
  3 1    1    1    1    1    1    1    1    1
  4 1    1    1    1    1    1    1    1    1

units:  NA

Slot "harvest":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002     2003     2004     2005     2006     2007     2008     2009
  0 0.038847 0.031211 0.033104 0.021328 0.034218 0.045611 0.016893 0.025596
  1 0.330442 0.416279 0.809397 0.275481 0.609364 0.839953 0.306289 0.401071
  2 0.626475 0.575094 1.174511 1.981938 1.991869 1.988679 1.705682 0.428553
  3 0.489380 0.507177 1.022443 1.164921 1.344104 1.462658 1.132993 0.510262
  4 0.489380 0.507177 1.022443 1.164921 1.344104 1.462658 1.132993 0.510262
   year
age 2010
  0 0.021727
  1 0.254007
  2 1.469962
  3 0.124692
  4 0.124692

units:  f

Slot "harvest.spwn":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002 2003 2004 2005 2006 2007 2008 2009 2010
  0 0    0    0    0    0    0    0    0    0
  1 0    0    0    0    0    0    0    0    0
  2 0    0    0    0    0    0    0    0    0
  3 0    0    0    0    0    0    0    0    0
  4 0    0    0    0    0    0    0    0    0

units:  NA

Slot "m.spwn":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 2002 2003 2004 2005 2006 2007 2008 2009 2010
  0 0    0    0    0    0    0    0    0    0
  1 0    0    0    0    0    0    0    0    0
  2 0    0    0    0    0    0    0    0    0
  3 0    0    0    0    0    0    0    0    0
  4 0    0    0    0    0    0    0    0    0

units:  NA

Slot "name":
[1] "BLACK SEA ANCHOVY Total,2010,COMBSEX,PLUSGROUP"

Slot "desc":
[1] "Imported from a VPA file. ( BSAn00IN_1_1.DAT ).  Thu Oct 13 15:56:37 2011 + FLAssess: "

Slot "range":
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         4         4      2002      2010         1         3
```

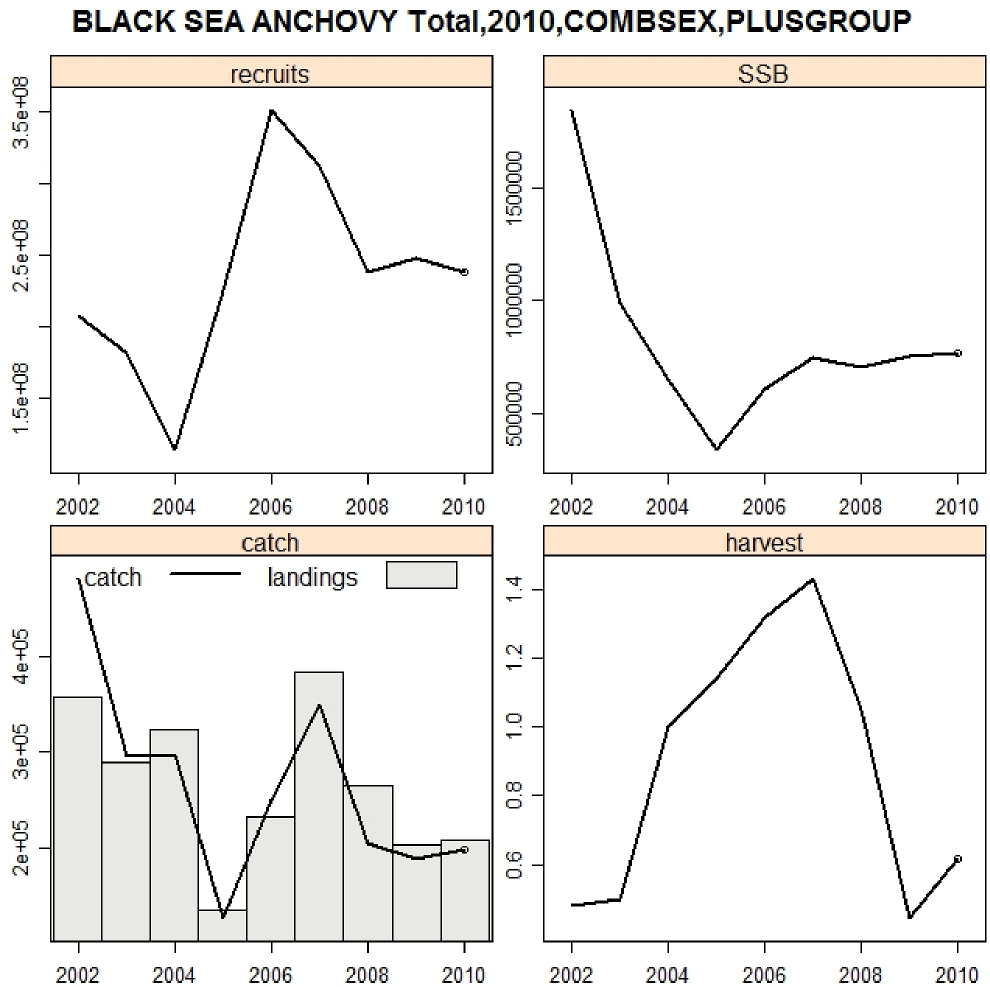


Fig. 6.3.4.1.3.3 Summary of trends in stock parameters of anchovy in the Black Sea.

7.3.5 Short term prediction of stock biomass and catch

7.3.5.1 Justification

A deterministic short term prediction of stock size and catch was performed

7.3.5.2 Input parameters

Represent short term averages of the stock parameters resented in the preceding section 6.3.4.

7.3.5.3 Results

As the stock is subject to overfishing with $F_{(1\text{-}3)}$=0.62 exceeding $E_{(1\text{-}3)}$=0.4 equals Fmsy $_{(1\text{-}3)}$=0.41 assuming $(M_{1\text{-}3})$=0.62), the resulting short term forcast indicates some dynamics in the relevant stock parameters: status quo catch 2011 equals 246 000 t while catch in 2012 is estimated at 256 000 t; if the stock is sustainably exploited at Fmsy(0.41), the catch in 2012 should not exceed 200 000 t.

Table 6.3.5.3.1 Short term projections of stock size and catches as management option table derived from various F-multipliers.

Fscenario	Fmult	Catch_2011	Catch_2012	Catch_2013	SSB_2011	SSB_2012	SSB_2013	ChangeSSB_2011_2013	ChangeCatch_2012_2010
0.53	0.86	245836	217135	224337	803217	793704	810271	0.9	8.8
0.00	0.00	245836	0	0	803217	793704	993279	23.7	-100.0
0.06	0.10	245836	34546	42255	803217	793704	963124	19.9	-82.7
0.12	0.20	245836	65924	78668	803217	793704	936031	16.5	-67.0
0.18	0.30	245836	94525	110129	803217	793704	911603	13.5	-52.6
0.25	0.40	245836	120691	137389	803217	793704	889498	10.7	-39.5
0.31	0.50	245836	144715	161082	803217	793704	869419	8.2	-27.5
0.37	0.60	245836	166855	181743	803217	793704	851110	6.0	-16.4
0.43	0.70	245836	187334	199826	803217	793704	834349	3.9	-6.1
0.49	0.80	245836	206346	215712	803217	793704	818945	2.0	3.4
0.55	0.90	245836	224061	229724	803217	793704	804730	0.2	12.3
0.62	1.00	245836	240625	242138	803217	793704	791562	-1.5	20.6
0.68	1.10	245836	256168	253184	803217	793704	779315	-3.0	28.4
0.74	1.20	245836	270801	263059	803217	793704	767882	-4.4	35.7
0.80	1.30	245836	284623	271928	803217	793704	757168	-5.7	42.7
0.86	1.40	245836	297718	279933	803217	793704	747093	-7.0	49.2
0.92	1.50	245836	310162	287194	803217	793704	737585	-8.2	55.5
0.99	1.60	245836	322020	293812	803217	793704	728583	-9.3	61.4
1.05	1.70	245836	333349	299874	803217	793704	720035	-10.4	67.1
1.11	1.80	245836	344200	305452	803217	793704	711893	-11.4	72.5
1.17	1.90	245836	354617	310610	803217	793704	704116	-12.3	77.7
1.23	2.00	245836	364639	315401	803217	793704	696671	-13.3	82.8

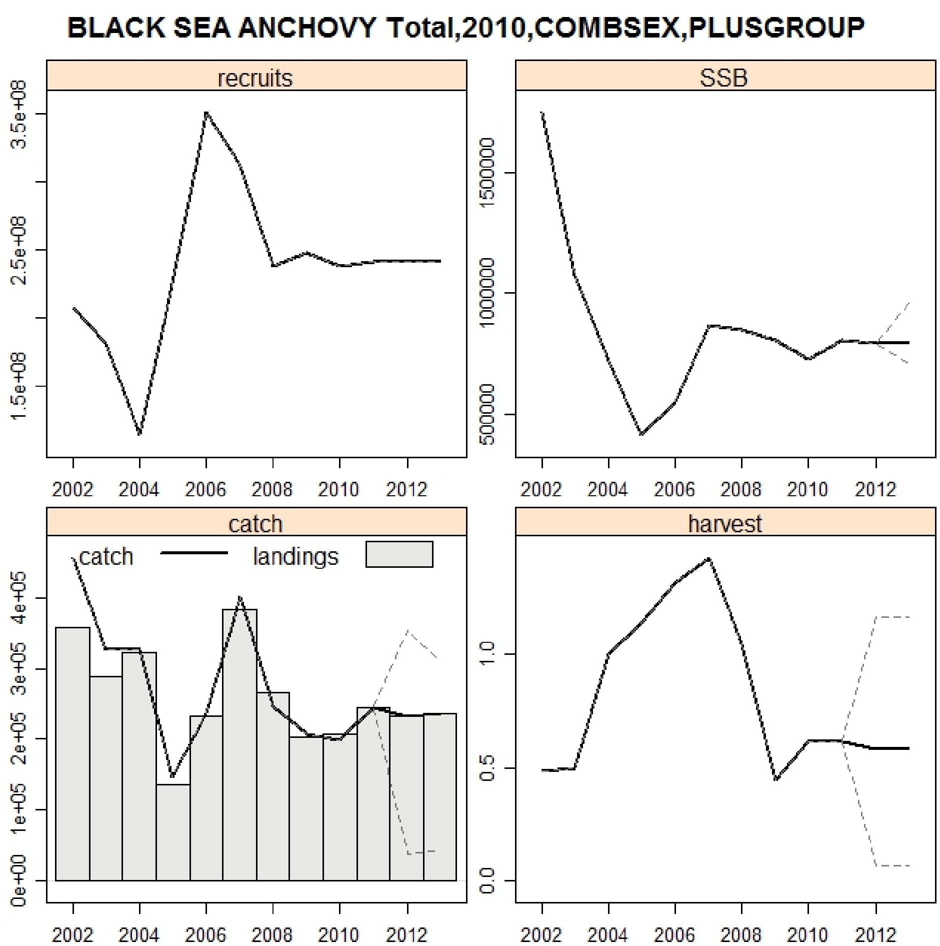


Table 6.3.5.3.1 Short term prediction of stock parameters assuming status quo fishing in 2011 and Fmsy in 2012.

7.3.6 Medium term prediction of stock biomass and catch

The WG did not undertake medium term projections.

7.3.7 Long term predictions

No analyses undertaken.

7.3.8 Scientific advice

7.3.8.1 Short term considerations

State of the spawning stock size: Following some drastic changes in stock size, the SSB is indicated to have remained rather stable around 800 000 t since 2007. In the absence of a precautionary reference point, the EWG cannot fully evaluate the stock size.

State of recruitment:
During the period 2002 to 2009 the recruitment has varied without a clear trend.

State of exploitation:
STECF EWG-11-16 proposes $E \leq 0.4$ as limit reference point consistent with high long term yield and low risk of fisheries collapses. The EWG classifies the stock as being subject to overfishing as the estimated $F_{(1\text{-}3)}=0.62$ exceeds such exploitation rate $E \leq 0.4$, which equals $F_{(1\text{-}3)}=0.41$, assuming an $M_{(1\text{-}3)}=0.62$.
The EWG-11-16 recommends the exploitation of anchovy to be sustainable and the catch in 2012 not to exceed 200 000 t.

7.3.8.2 Medium term considerations

Given the limited knowledge of the stock productivity (shortage of time series) and the lack of fisheries independent data (surveys) covering the entire distribution of anchovy in the Black Sea, the EWG did not perform analyses covering the medium term future.

7.4 Whiting in the Black Sea

7.4.1 Biological features

7.4.1.1 Stock Identification

In the Black Sea, the whiting is one of the most abundant species among the demersal fishes. It does not undertake distant migrations, spawning mainly in the cold season within the whole habitat area – Fig. 6.4.1.1.1. The whiting produces pelagic juveniles, which inhabit the upper 10-meter water layer for about a year. The adult whiting is cold-living, preferring temperatures 6-10º C. Fishes at the age less than 6 years are predominant in the whiting populations, the older year classes are found in catches individually. It occurs all along the shelf, dense commercial concentrations are formed by 1-3 year old fishes in the water down to 150 m depth, most often at 60-120 m depths. Such concentrations on the shelf of Bulgaria, Georgia, Romania, the Russian Federation and Ukraine not do from every year, appearing at periods of 4-6 years - in the years of appearance of highly productive year classes. In these countries, whiting is very rarely the target species for fisheries and yielded as by-catch during trawl fisheries for other fish species or while non-selective fisheries with fixed nets in the coastal sea areas.

In the vicinity of the southern coast of the Black Sea whiting concentrations are more stable. Turkey is the only country in the region, where the annual target trawling fisheries for this fish is conducted.

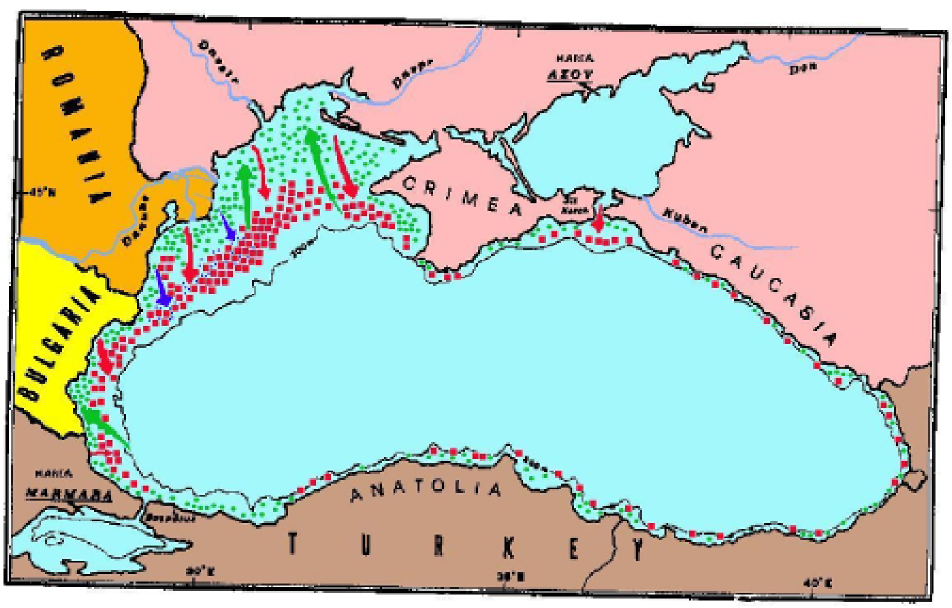


Fig. 6.4.1.1.1. Map of distribution of whiting in the Black Sea

The problem of units for whiting stocks in the Black Sea has not been settled yet. Fisheries experts from the Black Sea Commission specify the stock as shared that is although this fish does not make long migrations; its whole stock (or two different stocks – Eastern and Western) is exploited by each Black Sea country in their waters and for its adequate assessment the analysis of the regional data is required.

For last 15 years only one research was undertaken (Prodanov *et al*., 1997) that made possible to produce assessments of abundance and biomass of whiting in the Black Sea (separately for the «western» and «eastern» parts of the Black Sea) by VPA method for the period of 1971 – 1993 on the basis of analysis of regional biological and fishing data.

For the period of 1996 – 2008 there were no such assessments, but available assessments of whiting stock value were made for limited grounds with its habitat area.

In Romanian waters in 1996 – 2008 whiting remained the most abundant among bottom fishes although its mean annual catch reduced as much as four times as compared with 1989 – 1995. Partially it was caused by reduction of fishing efforts as compared with previous period (Nicolaev *et al.*, 2003). The stock biomass was assessed at 6000-9000 tons by swept area method.

Along Georgian coasts for last 10 years whiting biomass assessments were not made, but on the basis of monitoring the scientists from this country make conclusion that at present the whiting abundance as well as of other bottom fishes increase (Komakhidze, Diasamidze, Guchmanidze, 2003).

In the Russian sector of the Black Sea trawl survey show that stocks of whiting and other *Gadidae* (*Gaidrosparus mediterraneus*) are estimated about 7.6 – 8 thousand tons and the annual TAC for whiting averages 2 thousand tons (Volovik, Agapov, 2003).

Along the Turkish coasts the total trawlable biomass of whiting in local areas were estimated by A. İşmen (2003). In 1992 the highest biomass between Sinop and Sarp (eastern Black Sea), which is an area, closed to trawl fishing – 30 thousand tons. In 1990 the biomass of whiting between Sinop and İğneada (western Black Sea) was estimated within the range of 1.1 – 1.7 thousand tons. Even if for the period of 1996 – 2005 similar direct assessments of whiting biomass were made they were not published.

In 1992 – 1995 in the waters of Ukraine whiting biomass changed from 43 up to 70 thousand tons, on average 54 thousand tons, and for the subsequent decade – from 40 up to 68 thousand tons, on average 52 thousand tons (Shlyakhov, Charova, 2006). These data testify rather high inter-annual fluctuations but rather stable average level of whiting biomass in the specified areas where whiting specialized fisheries is almost absent and trawling fisheries are not conducted on the grounds with the densest whiting distribution.

By this reason the most realistic assessments of the stock abundance seem to be estimates according to the data of trawl surveys or surveys produced on the basis of analysis of fisheries with obligatory correction for unregistered catch. In order to make rough assessment of the present state of whiting stock and the extent of its exploitation by fisheries (underexploitation – exploitation at the target level – overfishing), let address to the assessments of allowable catch assessments in the various parts of the habitat area of this species.

As regards the levels of the reference points of whiting (Raykov *et al.*, 2008), in western part of the Black See the lowest level of F_{max} was established in Romanian waters: 0.52 and the middle level were established in Bulgarian waters: 0.61 and the highest - 0.68 was detected in Ukrainian waters. If to consider the value of this coefficient of natural mortality as constant and equal M = 0.70 (Prodanov *et al.*, 1997), and F_{max} = 0.60, so with favorable state of whiting population the highest level of annual capture makes up 33.6% of its initial stock.

7.4.1.2 Growth and mortality

The determination of the biologic parameters represents an important objective for the establishment of the demographic structure, the growth parameters, as well as other parameters required for the study of recruitment, mortality, effective and biomass, divided into age classes.

In the Black Sea for the grounds with relatively slight fished off whiting population was characteristic of predominance of larger-sized fishes than in the grounds with wide shelf (Shlyakhov, 1983). In 1996 – 2005 in the grounds of intensive Turkish trawl fisheries one can observe tendency to reduction of mean length of fishes which became equal or even less than in Ukrainian waters. It is not quite typical and in our opinion it is the evidence of excessive intensity of fishery. Turkish scientists came to the same conclusion. Thus, according to materials of 2000 Genç *et al.* (2002) applying methods of LCA and Thompson and Bell found that modern whiting fisheries in the waters of Turkey is conducted with excessive MSY due to trawls with mesh size less than 22 mm. İşmen (1995, 2006) estimates existing fishing intensity as F=1.24 and considers possible to achieve optimal exploitation of whiting by means of decrease in fishing intensity or enforcement of a minimum allowable total length. Thus, whiting stock in the waters of Turkey may be characterized as excessively exploited.

In front the Bulgarian coast whiting catch length composition ranged between 50 and 230 mm and individual weight between 3.08–86.2 g. The highest percent belongs to the 115-120 mm group, followed by 135-140 mm and 155-160 mm. The length group 85-90 mm, accounts around 6% of the whiting bycatch. The rest of the length groups are very weakly presented in the landings (Maximov et al., 2009, in press). The analysis performed by (Raykov et al., 2008), show that highest value for L asymptotic of the whiting was calculated in Ukranian waters (39 cm) with the lowest growth rate (k = 0.106), accordingly. In Bulgarian and Romanian marine area the values are very similar and lower, as regards the asymptotic length (Table 3.3.3.1).

Table. 6.4.1.2.1. Length growth of whiting in the North-Western part of the Black Sea (Raykov et al., 2008).

Merlangius merlangus euxinus(Nordm)						
$L_t = L\infty\ (1\text{-}e^{-k\,(t-t_0)})$	Age					
	1	2	3	4	5	6
Bulgaria						
$L_t = 29.83\ (1\text{-}e^{-0.157(t+2.49)})$	12.6	15.09	17.2	19.06	20.6	22.0
Romania						
$L_t = 26.3\ (1\text{-}e^{-0.16\,(t+2.19)})$	10.5	12.8	14.8	16.6	18.0	19.2
Ukraine						
$L_t = 39\ (1\text{-}e^{-0.106\,(t+1.324)})$	8.5	11.6	14.3	16.8	19.0	21.0

Overall, between 2004 and 2008, the whiting population on the Romanian littoral was homogenous, the length ranging between 40 and 230 mm/2.03–82.92 g, the dominant classes being those of 90-145 mm/5.50–23.84 g. The average body length was 107.45 mm, and the average weight 10.58g (Maximov et al., 2009, in press).

The analysis of age components during the entire Bulgarian fishing season emphasized the presence of individuals aged between $0;0^+$ to $5;5^+$ years, with a domination of individuals aged between $2;2^+$ years and $3;3^+$ years.

The analysis of age components during the entire Romanian fishing season emphasized the presence of individuals aged between $0;0^+$ to $4;4^+$ years, with a domination of individuals aged between$1;1^+$ years and 2;2+ years. The variation between sexes indicates a clear domination of the females (57.53%)(Maximov et al., 2009, in press).

In previuous studies (Prodanov et al. 1997, Daskalov 1998) an estimate of M = 0.7 has been applied over all age groups and year in VPA/XSA analyses. See also notes on M in the anchovy section,

7.4.1.3 Maturity

The maturity information used is presented in the analytical assessment described in the following sections.

7.4.2 Fisheries

7.4.2.1 General description

7.4.2.2 Management regulations applicable in 2010 and 2011

Not considering in details the similarity and differences of various measures of Black Sea whiting fisheries in various countries it should be noted that fishing in Turkey is conducted without limitation of annual catch or the fishing efforts.

7.4.2.3 Catches

7.4.2.3.1 Landings

The following table lists the whiting landings 1970-2009.

Table 6.4.2.3.1.1. Whiting landings (tons) by countries (FAO Fisheries Statistics, GFCM Capture Production 1970 - 2006, 2007 – 2009 from National Fisheries Statistics of countries).

Year	Bulgaria	Georgia	Romania	Russian Federation	Turkey	Ukraine	Un. Sov. Soc. Rep.
1970	-	.	115	.	4312	.	.
1971	-	.	442	.	5855	.	-
1972	-	.	416	.	5284	.	-
1973	-	.	329	.	2476	.	-
1974	-	.	1305	.	2844	.	-
1975	454	.	346	.	3913	.	-
1976	347	.	541	.	4213	.	-
1977	218	.	1495	.	5726	.	-
1978	407	.	1345	.	21265	.	531
1979	71	.	1205	.	20778	.	11377
1980	30	.	618	.	6838	.	2690
1981	1	.	894	.	4669	.	2238
1982	4	.	800	.	4264	.	1513
1983	-	.	1080	.	11696	.	2381
1984	-	.	1192	.	11595	.	4738
1985	-	.	3138	.	16036	.	2655
1986	-	.	1949	.	17738		2652
1987	-	.	615	.	27103		2764
1988	-	5	1009	736	28263	1482	-
1989	-	5	2738	7	19283	579	-
1990	-	-	2653	235	16259	87	-
1991	-	-	59	-	18956	24	-
1992	-	70	1357	-	17923	.	-
1993	-	172	599	16	17844	5	-
1994	-	187	432	125	15084	64	-
1995	-	146	327	91	17562	17	-
1996	-	223	372	11	20326	3	-
1997	-	58	441	10	12725	29	-
1998	-	53	640	119	11863	55	-
1999	-	41	272	184	12459	18	-
2000	9	.	275	341	15343	20	-
2001	8	32	306	642	7781	18	-
2002	16	37	85	656	7775	9	-
2003	13	45	113	93	7062	21	-
2004	2	29	118	55	7243	43	-
2005	3	30	92	78	6637	30	-
2006	0.5	37	113	60	7797	15	
2007	16.114	41	118	22	11232	64	
2008	0.44	15	92	96	10986	9	
2009	2.27		1	52	15905	17	

7.4.2.3.2 Discards

Discards, in particular of early life stages, are believed to be substantial and to be highly variable. However, no discard quantifications are available to EWG.

7.4.2.4 Fishing effort

Not provided.

7.4.2.5 Commercial CPUE

Not provided.

7.4.3 Scientific Surveys

7.4.3.1 Method 1: International (Bulgarian and Romanian) Bottom Trawl Surveys

The following section provides results obtained from various regional and internationally coordinated scientific programmes which can be taken as fishery independent information. The EWG will continue to work intersessionally to fully describe the methods used in a consistent way.

7.4.3.1.1 Geographical distribution patterns

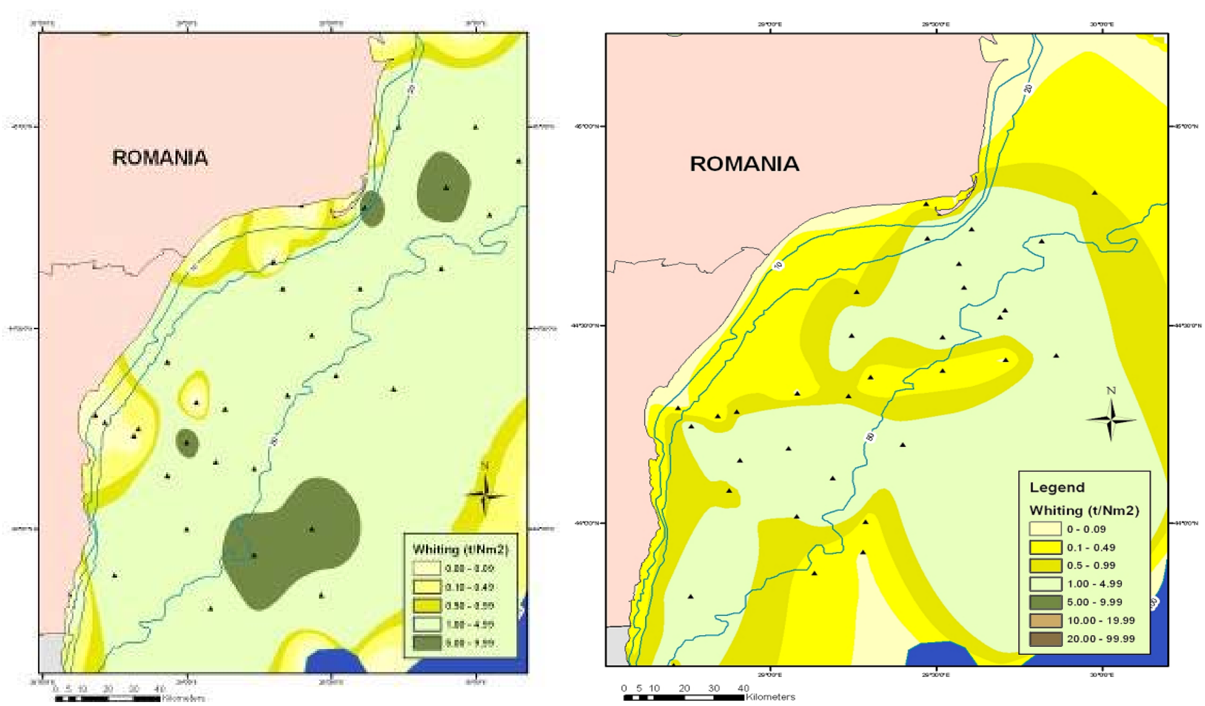


Fig. 6.4.3.1.1.1 Distribution of the whiting agglomerations at Romanian littoral in May 2009 and 2010.

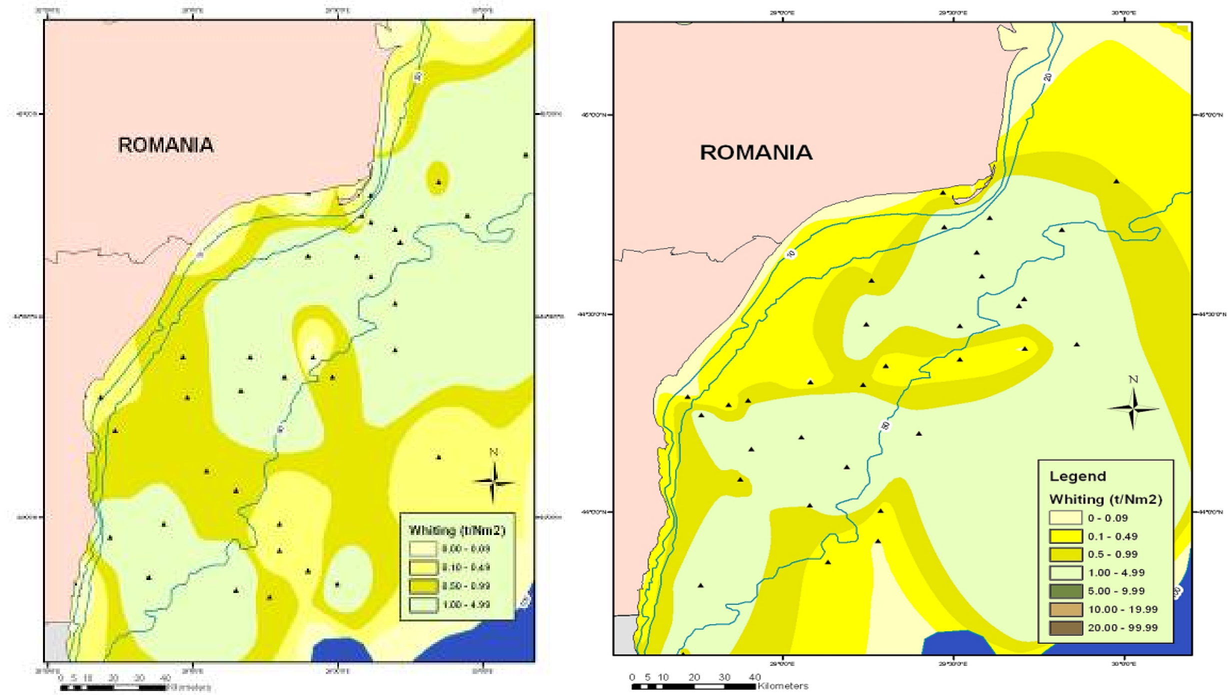


Fig. 6.4.3.1.1.2 Distribution of the whiting agglomerations at Romanian littoral in November 2009 and 2010.

7.4.3.1.2 Trends in abundance and biomass

In Romanian waters the swept area method was applied for stock assessment of whiting. Results for estimated whiting biomasses in May and November of 2009 and 2010 in Romanian waters are given on Tables 6.4.3.1.2.1-4. In May 2009 the biomass of whiting was evaluated at 11,853 tons, for the shelf till 50 Nm from the shore. In May 2010 the biomass of whiting was evaluated at 7,410 tons for the shelf till 50 Nm from the shore. In the autumn period the biomass agglomeration increased at 20,948 tons (2010).

Table 6.4.3.1.2.1 Assessment of the whiting fishing agglomeration in May 2009, demersal trawl.

No. polygon	Surveyed area (Nm^2)	Range (t/Nm^2)	Average (t/Nm^2)	Total tons in polygon (t)	Notes
1	356.38	0.00 – 0.08	0.04	14. 25	Extrapolated at 11,853 tons for the shelf till 50 Nm from shore
2	113.75	0.23 – 0.82	0.53	60.29	
3	2.329.30	1.16 – 4.40	2.80	6,522.30	
4	328.50	4.92 – 6.95	5.92	1,944.72	
5	90.00	5.79 – 6.20	6.0	540.00	
Total	3.218.01			9,081.56	

Table 6.4.3.1.2.2 Assessment of the whiting fishing agglomeration in November 2009, demersal trawl.

No. polygon	Surveyed area (Nm^2)	Range (t/Nm^2)	Average (t/Nm^2)	Total tons in polygon (t)	Notes
1	1.606.05	0.10 – 0.88	0.45	722.7	Extrapolated at 4,921 tons for the shelf till 50 Nm from shore
2	192.00	1.07 – 1.22	1.14	218.9	
3	360.00	1.11 – 1.82	1.37	493.2	
4	1.005.00	0.89 – 4.47	2.26	2,271.3	
Total	3.163.05			3,706.1	

Table 6.4.3.1.2.3 Assessment of **whiting** agglomeration in the Romanian area in the period May – June 2010, sampling gear demersal trawl.

No. polygon	Polygon area (Nm^2)	Range (t/Nm^2)	Average (t/Nm^2)	Total tons in polygon (t)	Total on the shelf (t)
1	209	0.08-0.24	0.17	35.53	Extrapolated at **7,410 tons** for the shelf till 50 Nm from shore (about 5000 Nm2), including the new area (near Snake Island)
2	950	0.055.22	1.97	1871.12	
3	265.25	0.00	0.0	0.0	
4	1145.75	0.36-3.17	1.66	1902	
Total	**2570**			**3809**	

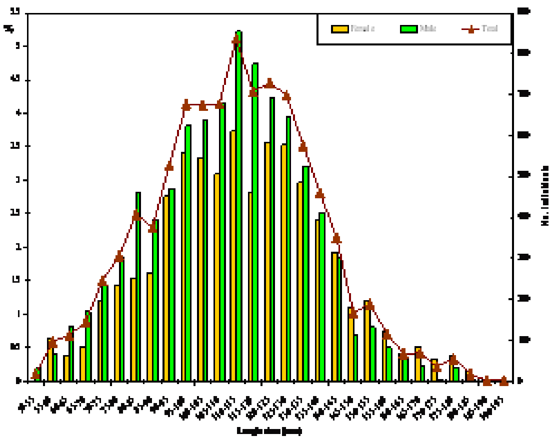
Table 6.4.3.1.2.4 Assessment of **whiting** agglomeration in the Romanian area in the period October **-** November 2010, sampling gear demersal trawl.

No. polygon	Polygon area (Nm^2)	Range (t/Nm^2)	Average (t/Nm^2)	Total tons in polygon (t)	Total on the shelf (t)
1	931.8	0.11-0.54	0.23	223.6	Extrapolated at **20,948 tons** for the shelf till 50 Nm from shore (about 5000 Nm2), including the new area near (Snake Island)
2	450	0.55-1.1	0.73	328.5	
3	1303.1	0.55-8.88	3.29	4287.2	
4	299.6	10.1-27.41	21.03	6300.6	
5	66.4	24.67	24.67	1638.1	
TOTAL	**3050**			**12778**	

7.4.3.1.3 Trends in abundance at length or age

Overall, in 2010, the whiting population at the Romanian coast was homogeneous, length range between 50-235 mm / 1.03 to 165.21 g, the dominant classes being 90-130 mm / 6.00 to 15.47 g. The average body length was 105.099mm and average mass of 10.300 g.

Analysis of the age composition of the entire fishing season revealed the occurrence of 0;0+ to 5;5+ years, with a dominance of individuals of 1;1+ years (58.21%), 2; 2 + years (21 , 69%) and 0; 0 + years (16.53%). The report indicates a slight dominance of females (52.29%).



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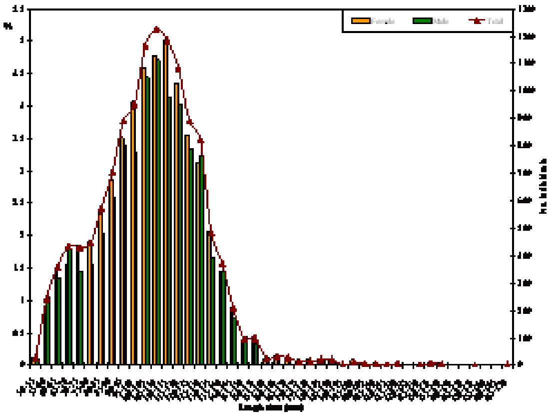
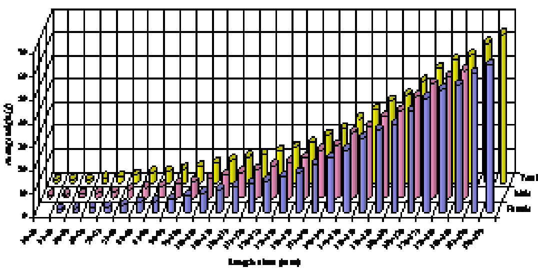


2

Fig. Structure on length classes for whiting in 2009 and 2010, Romanian littoral



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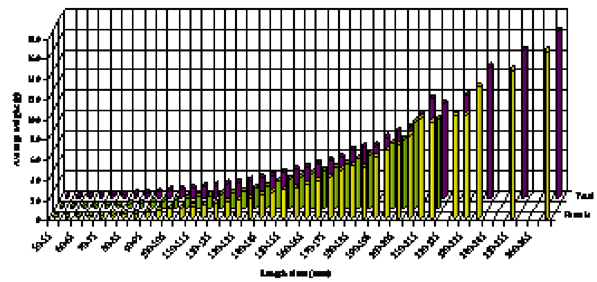
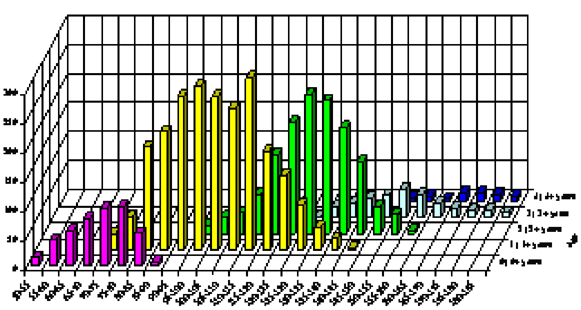


2

Fig. Mean weight on length classes for whiting in 2009 and 2010, Romanian littoral



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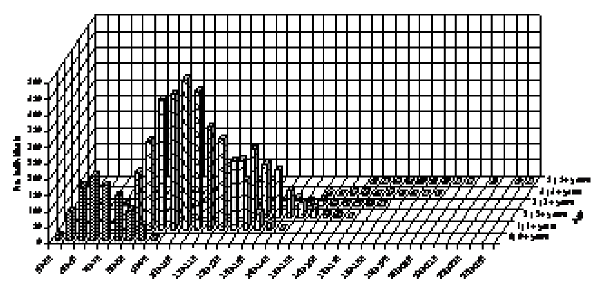
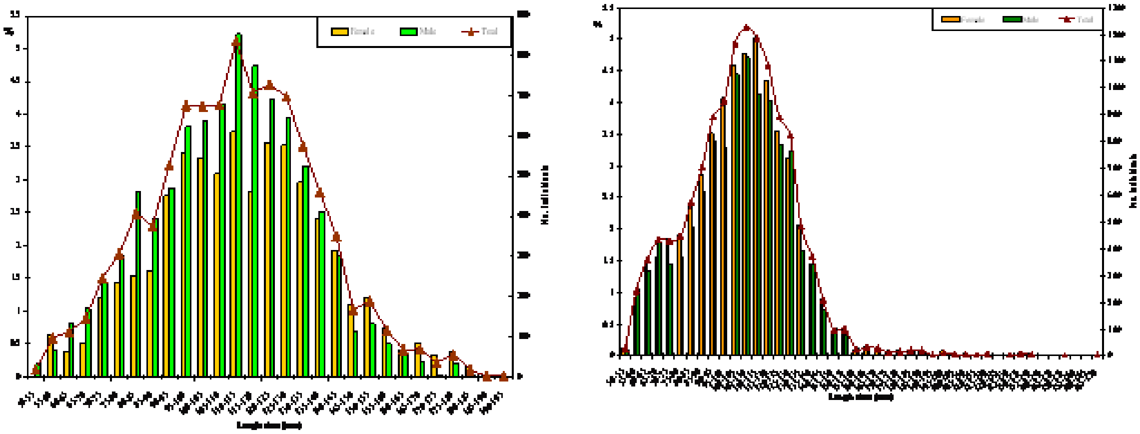


2

Fig. Structure on length classes and age for whiting in 2009 and 2010, Romanian littoral

Fig. 6.4.3.1.3.1 Age and length compositions.



1 2

Fig. Structure on length classes for whiting in 2009 and 2010, Romanian littoral

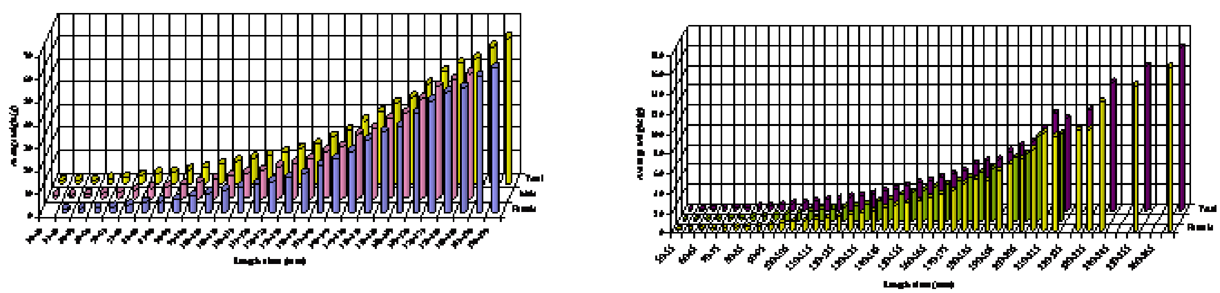


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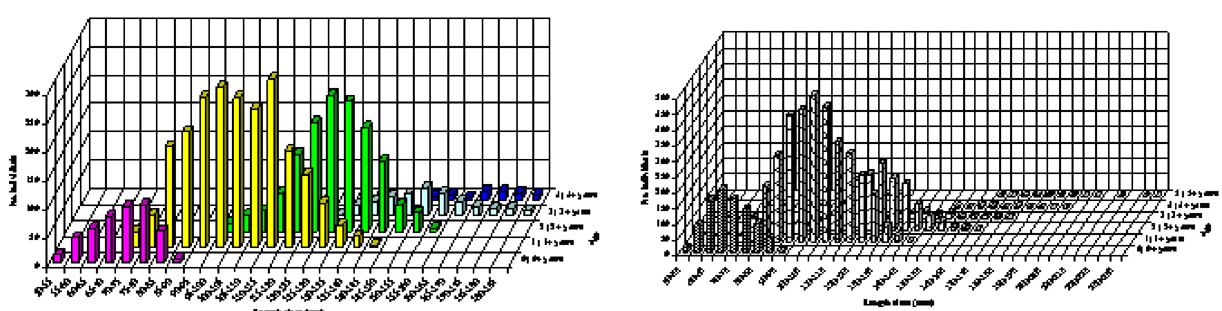
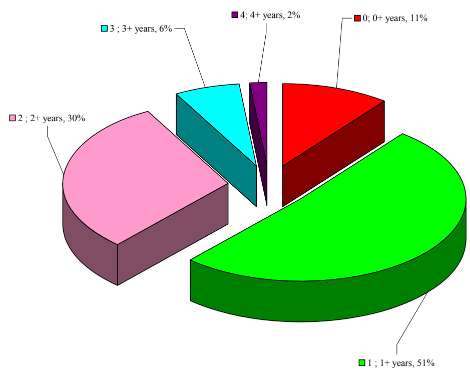
Fig. Mean weight on length classes for whiting in 2009 and 2010, Romanian littoral



1 2

Fig. Structure on length classes and age for whiting in 2009 and 2010, Romanian littoral

Fig. 6.4.3.1.3.2 Age and length compositions.



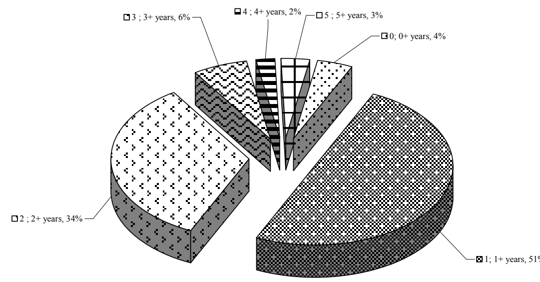


Fig. 6.4.3.1.3.3 Age compositions.

7.4.3.1.4 Trends in growth

No data presented.

7.4.3.1.5 Trends in maturity

No data presented.

7.4.4 Assessment of historic parameters

7.4.4.1 Method 1: XSA

7.4.4.1.1 Justification

An XSA formulation has been accomplished as being documented in the following sections.

7.4.4.1.2 Input parameters

```
An object of class "FLStock"
Slot "catch":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

     year
age   1994    1995    1996    1997    1998    1999    2000    2001    2002
  all 14178.5 16628.1 18777.8 11732.5 11054.2 11276.0 14103.0  8263.9  8142.2
     year
age   2003    2004    2005    2006    2007    2008    2009    2010
  all  6189.7  7084.2  6511.4  7881.9 10186.0  9813.0  7058.6 16656.1

units:  NA NA

Slot "catch.n":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 1994       1995       1996       1997       1998       1999
  0  725937.01 1092595.53  879500.98  904890.59  256595.16  265980.14
  1  475158.77  715153.44  722334.15  235673.73  323720.69  399201.63
  2  107202.98   47180.26  286057.69  222631.81  197953.34  183594.18
  3  103846.70   81121.67   56801.10   48131.56   45023.22   40961.56
  4   19147.77   16147.71   15904.31    1127.52   22920.91   21117.19
```

```
  5     301.69    9095.50    1627.08       7.18    2567.44    3085.62
  6       0.00    1702.75     850.18       0.00      58.29      58.99
   year
age 2000       2001       2002       2003       2004       2005
  0  294841.89  510544.98   31282.32   62379.46  297376.13  364318.63
  1  512696.83  266594.48   58047.50   76705.04   72456.79  299570.30
  2  179416.21   93222.54   72623.95   74840.27  130642.68   15319.49
  3   39082.10   27994.96   38878.11   28776.53   40633.52   36069.20
  4   20465.23    6087.16   35817.47   23065.17    9376.14    5722.43
  5    3886.40    2666.76   17162.60   15820.72    1084.49    1430.65
  6    3081.73    1142.45    5503.14    2014.74    3163.57     242.78
   year
age 2006       2007       2008       2009       2010
  0   89993.80  126843.71   74007.68  364622.10    9503.24
  1  251321.76  311178.82  298546.71   85622.41  302335.85
  2  140257.69  170900.13  171954.42  158282.23  456093.59
  3   16029.94   33535.86   33404.47   49470.23  145288.59
  4   19023.90   13376.43   24181.05   11334.99   31249.63
  5    5540.56   11235.51    7254.26    1333.52    5710.11
  6     273.90    2701.71     707.21    1250.68     866.66

units:  NA

Slot "catch.wt":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 1994  1995  1996  1997  1998  1999  2000  2001  2002  2003  2004  2005
  0 0.004 0.004 0.004 0.004 0.004 0.004 0.004 0.004 0.005 0.004 0.004 0.004
  1 0.009 0.009 0.009 0.009 0.009 0.009 0.011 0.010 0.012 0.010 0.010 0.010
  2 0.019 0.019 0.019 0.019 0.019 0.019 0.021 0.020 0.023 0.020 0.021 0.019
  3 0.035 0.035 0.035 0.035 0.035 0.035 0.038 0.035 0.037 0.037 0.037 0.037
  4 0.068 0.068 0.068 0.068 0.068 0.068 0.067 0.063 0.058 0.052 0.052 0.053
  5 0.082 0.082 0.082 0.082 0.082 0.082 0.081 0.075 0.077 0.075 0.075 0.072
  6 0.000 0.142 0.142 0.000 0.142 0.142 0.112 0.112 0.142 0.112 0.112 0.109
   year
age 2006  2007  2008  2009  2010
  0 0.004 0.004 0.004 0.003 0.003
  1 0.010 0.010 0.010 0.009 0.008
  2 0.020 0.020 0.020 0.018 0.017
  3 0.036 0.037 0.033 0.031 0.030
  4 0.060 0.055 0.057 0.051 0.050
  5 0.082 0.075 0.074 0.070 0.072
  6 0.112 0.122 0.106 0.112 0.142

units:  NA

Slot "discards":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

     year
age   1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
  all 0    0    0    0    0    0    0    0    0    0    0    0    0    0
     year
age   2008 2009 2010
  all 0    0    0

units:  NA

Slot "discards.n":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008
  0 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  1 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  2 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  3 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  4 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  5 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  6 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   year
age 2009 2010
  0 0    0
  1 0    0
  2 0    0
```

```
  3 0    0
  4 0    0
  5 0    0
  6 0    0

units:  NA

Slot "discards.wt":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008
  0 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  1 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  2 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  3 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  4 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  5 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  6 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   year
age 2009 2010
  0 0    0
  1 0    0
  2 0    0
  3 0    0
  4 0    0
  5 0    0
  6 0    0

units:  NA

Slot "landings":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

     year
age   1994    1995    1996    1997    1998    1999    2000    2001    2002
  all 15892.0 18143.0 20952.0 13263.0 12730.0 12974.4 15979.0  8779.0  8562.0
     year
age   2003    2004    2005    2006    2007    2008    2009    2010
  all  7334.4  7487.6  6868.3  8005.7 11376.1 11161.2  9087.5 11957.6

units:  NA

Slot "landings.n":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 1994       1995       1996       1997       1998       1999
  0  725937.01 1092595.53  879500.98  904890.59  256595.16  265980.14
  1  475158.77  715153.44  722334.15  235673.73  323720.69  399201.63
  2  107202.98   47180.26  286057.69  222631.81  197953.34  183594.18
  3  103846.70   81121.67   56801.10   48131.56   45023.22   40961.56
  4   19147.77   16147.71   15904.31    1127.52   22920.91   21117.19
  5     301.69    9095.50    1627.08       7.18    2567.44    3085.62
  6       0.00    1702.75     850.18       0.00      58.29      58.99
   year
age 2000       2001       2002       2003       2004       2005
  0  294841.89  510544.98   31282.32   62379.46  297376.13  364318.63
  1  512696.83  266594.48   58047.50   76705.04   72456.79  299570.30
  2  179416.21   93222.54   72623.95   74840.27  130642.68   15319.49
  3   39082.10   27994.96   38878.11   28776.53   40633.52   36069.20
  4   20465.23    6087.16   35817.47   23065.17    9376.14    5722.43
  5    3886.40    2666.76   17162.60   15820.72    1084.49    1430.65
  6    3081.73    1142.45    5503.14    2014.74    3163.57     242.78
   year
age 2006       2007       2008       2009       2010
  0   89993.80  126843.71   74007.68  364622.10    9503.24
  1  251321.76  311178.82  298546.71   85622.41  302335.85
  2  140257.69  170900.13  171954.42  158282.23  456093.59
  3   16029.94   33535.86   33404.47   49470.23  145288.59
  4   19023.90   13376.43   24181.05   11334.99   31249.63
  5    5540.56   11235.51    7254.26    1333.52    5710.11
  6     273.90    2701.71     707.21    1250.68     866.66

units:  NA
```

```
Slot "landings.wt":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 1994  1995  1996  1997  1998  1999  2000  2001  2002  2003  2004  2005 
  0 0.004 0.004 0.004 0.004 0.004 0.004 0.004 0.004 0.005 0.004 0.004 0.004
  1 0.009 0.009 0.009 0.009 0.009 0.009 0.011 0.010 0.012 0.010 0.010 0.010
  2 0.019 0.019 0.019 0.019 0.019 0.019 0.021 0.020 0.023 0.020 0.021 0.019
  3 0.035 0.035 0.035 0.035 0.035 0.035 0.038 0.035 0.037 0.037 0.037 0.037
  4 0.068 0.068 0.068 0.068 0.068 0.068 0.067 0.063 0.058 0.052 0.052 0.053
  5 0.082 0.082 0.082 0.082 0.082 0.082 0.081 0.075 0.077 0.075 0.075 0.072
  6 0.000 0.142 0.142 0.000 0.142 0.142 0.112 0.112 0.142 0.112 0.112 0.109
   year
age 2006  2007  2008  2009  2010 
  0 0.004 0.004 0.004 0.003 0.003
  1 0.010 0.010 0.010 0.009 0.008
  2 0.020 0.020 0.020 0.018 0.017
  3 0.036 0.037 0.033 0.031 0.030
  4 0.060 0.055 0.057 0.051 0.050
  5 0.082 0.075 0.074 0.070 0.072
  6 0.112 0.122 0.106 0.112 0.142

units:  NA 

Slot "stock":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

     year
age   1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
  all 0    0    0    0    0    0    0    0    0    0    0    0    0    0   
     year
age   2008 2009 2010
  all 0    0    0   

units:  NA * NA 

Slot "stock.n":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 1994       1995       1996       1997       1998       1999      
  0 7.3350e+06 7.6298e+06 5.6356e+06 6.2483e+06 5.4154e+06 4.1601e+06
  1 1.2203e+06 2.4649e+06 2.3509e+06 1.6907e+06 1.9188e+06 1.9961e+06
  2 4.3111e+05 2.5822e+05 6.9139e+05 6.3147e+05 6.5114e+05 6.9997e+05
  3 1.8818e+05 1.4948e+05 1.0190e+05 1.5684e+05 1.7131e+05 1.9960e+05
  4 5.2769e+04 2.5702e+04 2.1422e+04 1.3496e+04 4.9741e+04 5.9892e+04
  5 6.1546e+02 1.4995e+04 2.2247e+03 3.3531e+01 6.6419e+03 1.0508e+04
  6 0.0000e+00 2.5686e+03 9.9281e+02 0.0000e+00 1.4369e+02 1.9346e+02
   year
age 2000       2001       2002       2003       2004       2005      
  0 2.9365e+06 3.2871e+06 3.5471e+06 1.5729e+06 3.8335e+06 4.2068e+06
  1 1.4900e+06 9.8414e+05 9.8768e+05 1.3938e+06 5.8743e+05 1.3400e+06
  2 6.8483e+05 3.6211e+05 2.8920e+05 4.3568e+05 6.1846e+05 2.3279e+05
  3 2.3577e+05 2.3083e+05 1.2325e+05 9.9755e+04 1.7538e+05 2.3124e+05
  4 7.8259e+04 9.9299e+04 1.0478e+05 3.8308e+04 3.2990e+04 6.5343e+04
  5 1.7478e+04 2.8144e+04 5.0512e+04 3.1417e+04 4.0626e+03 1.1307e+04
  6 1.3438e+04 1.1813e+04 1.5520e+04 3.7461e+03 1.1444e+04 1.8754e+03
   year
age 2006       2007       2008       2009       2010      
  0 5.4570e+06 8.5416e+06 8.6788e+06 5.6982e+06 9.9346e+05
  1 1.4465e+06 2.1179e+06 3.3239e+06 3.4119e+06 2.0406e+06
  2 4.3779e+05 5.2262e+05 8.0461e+05 1.3946e+06 1.5848e+06
  3 1.1162e+05 1.2899e+05 1.5147e+05 2.9940e+05 6.2042e+05
  4 9.9058e+04 4.8835e+04 4.5369e+04 5.7680e+04 1.2621e+05
  5 3.1961e+04 4.0747e+04 1.7112e+04 7.1456e+03 2.3534e+04
  6 1.5386e+03 9.4530e+03 1.5817e+03 6.5186e+03 3.4571e+03

units:  NA 

Slot "stock.wt":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 1994  1995  1996  1997  1998  1999  2000  2001  2002  2003  2004  2005 
  0 0.004 0.004 0.004 0.004 0.004 0.004 0.004 0.004 0.005 0.004 0.004 0.004
```

```
  1 0.009 0.009 0.009 0.009 0.009 0.009 0.011 0.010 0.012 0.010 0.010 0.010
  2 0.019 0.019 0.019 0.019 0.019 0.019 0.021 0.020 0.023 0.020 0.021 0.019
  3 0.035 0.035 0.035 0.035 0.035 0.035 0.038 0.035 0.037 0.037 0.037 0.037
  4 0.068 0.068 0.068 0.068 0.068 0.068 0.067 0.063 0.058 0.052 0.052 0.053
  5 0.082 0.082 0.082 0.082 0.082 0.082 0.081 0.075 0.077 0.075 0.075 0.072
  6 0.000 0.142 0.142 0.000 0.142 0.142 0.112 0.112 0.142 0.112 0.112 0.109
   year
age 2006  2007  2008  2009  2010
  0 0.004 0.004 0.004 0.003 0.003
  1 0.010 0.010 0.010 0.009 0.008
  2 0.020 0.020 0.020 0.018 0.017
  3 0.036 0.037 0.033 0.031 0.030
  4 0.060 0.055 0.057 0.051 0.050
  5 0.082 0.075 0.074 0.070 0.072
  6 0.112 0.122 0.106 0.112 0.142

units:  NA

Slot "m":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008
  0 0.92 0.92 0.92 0.92 0.92 0.92 0.92 0.92 0.92 0.92 0.92 0.92 0.92 0.92 0.92
  1 0.73 0.73 0.73 0.73 0.73 0.73 0.73 0.73 0.73 0.73 0.73 0.73 0.73 0.73 0.73
  2 0.64 0.64 0.64 0.64 0.64 0.64 0.64 0.64 0.64 0.64 0.64 0.64 0.64 0.64 0.64
  3 0.61 0.61 0.61 0.61 0.61 0.61 0.61 0.61 0.61 0.61 0.61 0.61 0.61 0.61 0.61
  4 0.59 0.59 0.59 0.59 0.59 0.59 0.59 0.59 0.59 0.59 0.59 0.59 0.59 0.59 0.59
  5 0.58 0.58 0.58 0.58 0.58 0.58 0.58 0.58 0.58 0.58 0.58 0.58 0.58 0.58 0.58
  6 0.58 0.58 0.58 0.58 0.58 0.58 0.58 0.58 0.58 0.58 0.58 0.58 0.58 0.58 0.58
   year
age 2009 2010
  0 0.92 0.92
  1 0.73 0.73
  2 0.64 0.64
  3 0.61 0.61
  4 0.59 0.59
  5 0.58 0.58
  6 0.58 0.58

units:  NA

Slot "mat":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008
  0 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25
  1 0.90 0.90 0.90 0.90 0.90 0.90 0.90 0.90 0.90 0.90 0.90 0.90 0.90 0.90 0.90
  2 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  3 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  4 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  5 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
  6 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
   year
age 2009 2010
  0 0.25 0.25
  1 0.90 0.90
  2 1.00 1.00
  3 1.00 1.00
  4 1.00 1.00
  5 1.00 1.00
  6 1.00 1.00

units:  NA

Slot "harvest":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 1994     1995     1996     1997     1998     1999     2000     2001
  0 0.170520 0.257270 0.283975 0.260598 0.078024 0.106783 0.173221 0.282407
  1 0.823043 0.541196 0.584493 0.224148 0.278428 0.339795 0.684546 0.494661
  2 0.419226 0.289846 0.843459 0.664596 0.542419 0.448172 0.447517 0.437771
  3 1.380858 1.332727 1.411541 0.538402 0.440910 0.326292 0.254734 0.179766
  4 0.668191 1.856937 5.869710 0.119018 0.964731 0.641630 0.432690 0.085924
```

```
  5 1.064511 1.663989 3.790836 0.337113 0.726903 0.498316 0.352646 0.135399
  6 1.064511 1.663989 3.790836 0.337113 0.726903 0.498316 0.352646 0.135399
   year
age 2002     2003     2004     2005     2006     2007     2008     2009
  0 0.014069 0.064885 0.131115 0.147554 0.026471 0.023805 0.013600 0.106877
  1 0.088461 0.082592 0.195625 0.388677 0.288057 0.237816 0.138553 0.036819
  2 0.424386 0.269924 0.343764 0.094999 0.581969 0.598442 0.348575 0.169960
  3 0.558522 0.496507 0.377326 0.237759 0.216689 0.434940 0.355501 0.253803
  4 0.614545 1.653839 0.480828 0.125138 0.298332 0.458700 1.258331 0.306452
  5 0.605289 1.117756 0.441222 0.185247 0.263543 0.459669 0.836014 0.286891
  6 0.605289 1.117756 0.441222 0.185247 0.263543 0.459669 0.836014 0.286891
   year
age 2010
  0 0.015269
  1 0.240063
  2 0.504720
  3 0.382276
  4 0.404286
  5 0.391944
  6 0.391944

units:  f

Slot "harvest.spwn":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008
  0 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  1 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  2 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  3 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  4 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  5 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  6 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   year
age 2009 2010
  0 0    0
  1 0    0
  2 0    0
  3 0    0
  4 0    0
  5 0    0
  6 0    0

units:  NA

Slot "m.spwn":
An object of class "FLQuant"
, , unit = unique, season = all, area = unique

   year
age 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008
  0 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  1 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  2 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  3 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  4 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  5 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  6 0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   year
age 2009 2010
  0 0    0
  1 0    0
  2 0    0
  3 0    0
  4 0    0
  5 0    0
  6 0    0

units:  NA

Slot "name":
[1] "BLACK SEA WHITING,2010,COMBSEX,PLUSGROUP,INDEX FILE"

Slot "desc":
[1] "Imported from a VPA file. ( BSW_94_2010IND.DAT ).   Fri Oct 14 09:34:37 2011 + FLAssess:   +
FLAssess:  + FLAssess:  + FLAssess:  + FLAssess:  + FLAssess:  + FLAssess:  + FLAssess: "
```

```
Slot "range":
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         6         6      1994      2010         1         4

Tuning data

BLACK SEA Whiting Total,2010,COMBSEX,TUNING DATA(effort, nos at age)
101
RO Trawl fleet
2008 2010
1      1        0.40        0.50
0  3
1       35.84   523.36  217.76  23.04
1       90.185  434.18  257.72  54.485
1       148.77  523.89  195.21  21.69
```

7.4.4.1.3 Diagnostics and results

After several tries the EWG has chosen a very light shrinkage in order to downweigth the trends in catchability residuals for the recruiting year class caused by very high tuning indices in the survey.

```
FLR XSA Diagnostics 2011-10-14 10:41:50

CPUE data from bsw.idx

Catch data for 17 years 1994 to 2010. Ages 0 to 6.

           fleet first age last age first year last year alpha beta
1 RO Trawl fleet         0         3       2008      2010  <NA> <NA>


 Time series weights :

    Tapered time weighting applied
   Power =   3 over  20 years

 Catchability analysis :

     Catchability independent of size for ages >   1

     Catchability independent of age for ages >   3

 Terminal population estimation :

     Survivor estimates shrunk towards the mean F
    of the final   5 years or the  2 oldest ages.

    S.E. of the mean to which the estimates are shrunk =   2

    Minimum standard error for population
    estimates derived from each fleet =  0.3

    prior weighting not applied

Regression weights
     year
age    2001 2002  2003  2004  2005  2006 2007  2008 2009 2010
  all 0.751 0.82 0.877 0.921 0.954 0.976 0.99 0.997    1    1


 Fishing mortalities
   year
age  2001  2002  2003  2004  2005  2006  2007  2008  2009  2010
  0 0.274 0.014 0.061 0.127 0.130 0.022 0.035 0.021 0.108 0.004
  1 0.489 0.085 0.079 0.181 0.374 0.246 0.191 0.215 0.058 0.243
  2 0.436 0.416 0.258 0.327 0.087 0.547 0.472 0.262 0.291 0.992
  3 0.179 0.555 0.481 0.355 0.223 0.196 0.394 0.249 0.176 0.866
  4 0.085 0.609 1.619 0.457 0.116 0.274 0.399 1.005 0.192 0.250
  5 0.135 0.600 1.092 0.418 0.173 0.241 0.407 0.648 0.188 0.212
  6 0.135 0.600 1.092 0.418 0.173 0.241 0.407 0.648 0.188 0.212


 XSA population number (Thousand)
      age
year         0       1       2      3      4     5     6
```

```
  2001 3374757  993670  363254 232189  99847 28308 11882
  2002 3682352 1022606  293790 123847 105524 50816 15617
  2003 1678140 1447739  452507 102177  38635 31828  3799
  2004 3940033  629392  644430 184258  34306  4243 11966
  2005 4742680 1382450  253010 244937  70165 12036  1998
  2006 6613137 1660060  458254 122286 106499 34634  1669
  2007 5774289 2578649  625531 139786  54628 44872 10436
  2008 5625400 2221090 1026655 205739  51233 20323  1895
  2009 5644494 2195109  863113 416483  87165 10396  9529
  2010 3760940 2019258  998404 340176 189831 39879  5908


 Estimated population abundance at 1st Jan  2011
      age
year        0       1      2      3     4     5     6
  2011 1034399 1493228 763512 195425 77899 82121 18106


 Fleet:  RO Trawl fleet

 Log catchability residuals.

   year
age   2008   2009   2010
  0 -0.534  0.028  0.533
  1  0.032 -0.080  0.087
  2 -0.201  0.154  0.046
  3  0.055  0.177 -0.231

 Regression statistics
 Ages with q dependent on year class strength
[1] "0.587233264697722"    "0.47306935773668"     "2.41630333329071e-05"
[4] "0.000333973624964814"


 Terminal year survivor and F summaries:

 ,Age 0 Year class =2010

source
               scaledWts survivors yrcls
RO Trawl fleet     0.052   3702244  2010
fshk               0.037     88378  2010
nshk               0.911   1590343  2010

 ,Age 1 Year class =2009

source
               scaledWts survivors yrcls
RO Trawl fleet     0.968    916690  2009
fshk               0.032    836848  2009

 ,Age 2 Year class =2008

source
               scaledWts survivors yrcls
RO Trawl fleet     0.943    204367  2008
fshk               0.057    812809  2008

 ,Age 3 Year class =2007

source
               scaledWts survivors yrcls
RO Trawl fleet     0.949     61674  2007
fshk               0.051    371072  2007

 ,Age 4 Year class =2006

source
     scaledWts survivors yrcls
fshk         1     46127  2006

 ,Age 5 Year class =2005

source
     scaledWts survivors yrcls
fshk         1      5492  2005
```

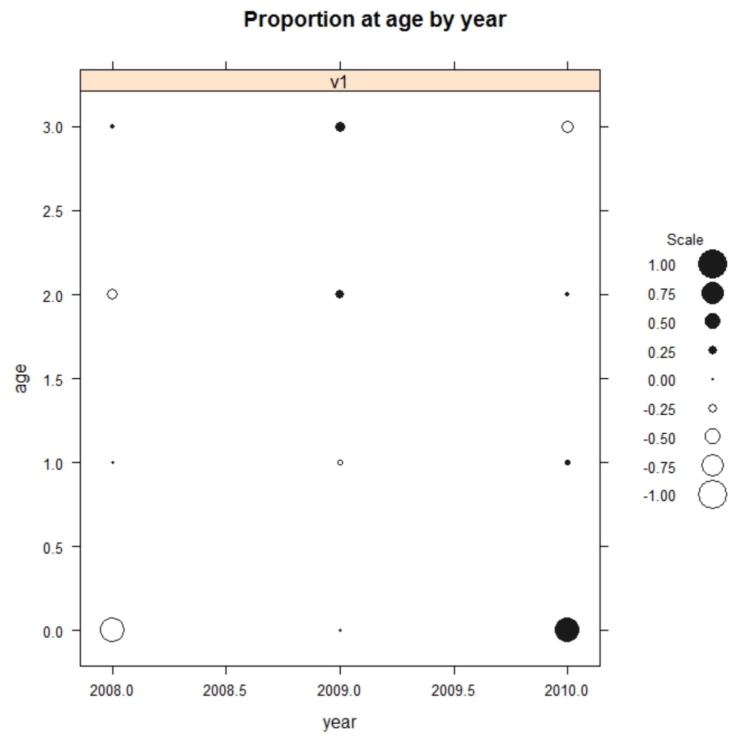


Fig. 6.4.4.1.3.1 Residuals of log transformed catchability applying a very low shrinkage of 2.0.

Table 6.4.4.1.3.1 Summary table of stock parameters. Fbar is estimated over ages 1-4.

Year	ssb (tons)	fbar	rec (000)	catch (t)	landings (t
1994	35637	0.823	7335825	14178	15892
1995	41081	1.005	7632112	16628	18143
1996	43177	2.177	5640932	18778	20952
1997	38390	0.386	6258245	11732	13263
1998	43350	0.556	5428836	11054	12730
1999	45691	0.438	4166015	11276	12974
2000	49364	0.453	2960459	14103	15979
2001	37454	0.297	3374757	8264	8779
2002	39237	0.416	3682352	8142	8562
2003	32360	0.610	1678140	6190	7334
2004	33398	0.330	3940033	7084	7488
2005	35858	0.200	4742680	6511	6868
2006	44538	0.316	6613137	7882	8006
2007	54308	0.364	5774289	10186	11376
2008	57563	0.433	5625400	9813	11161
2009	56701	0.179	5644494	7059	9088
2010	57739	0.588	3760940	16656	11958

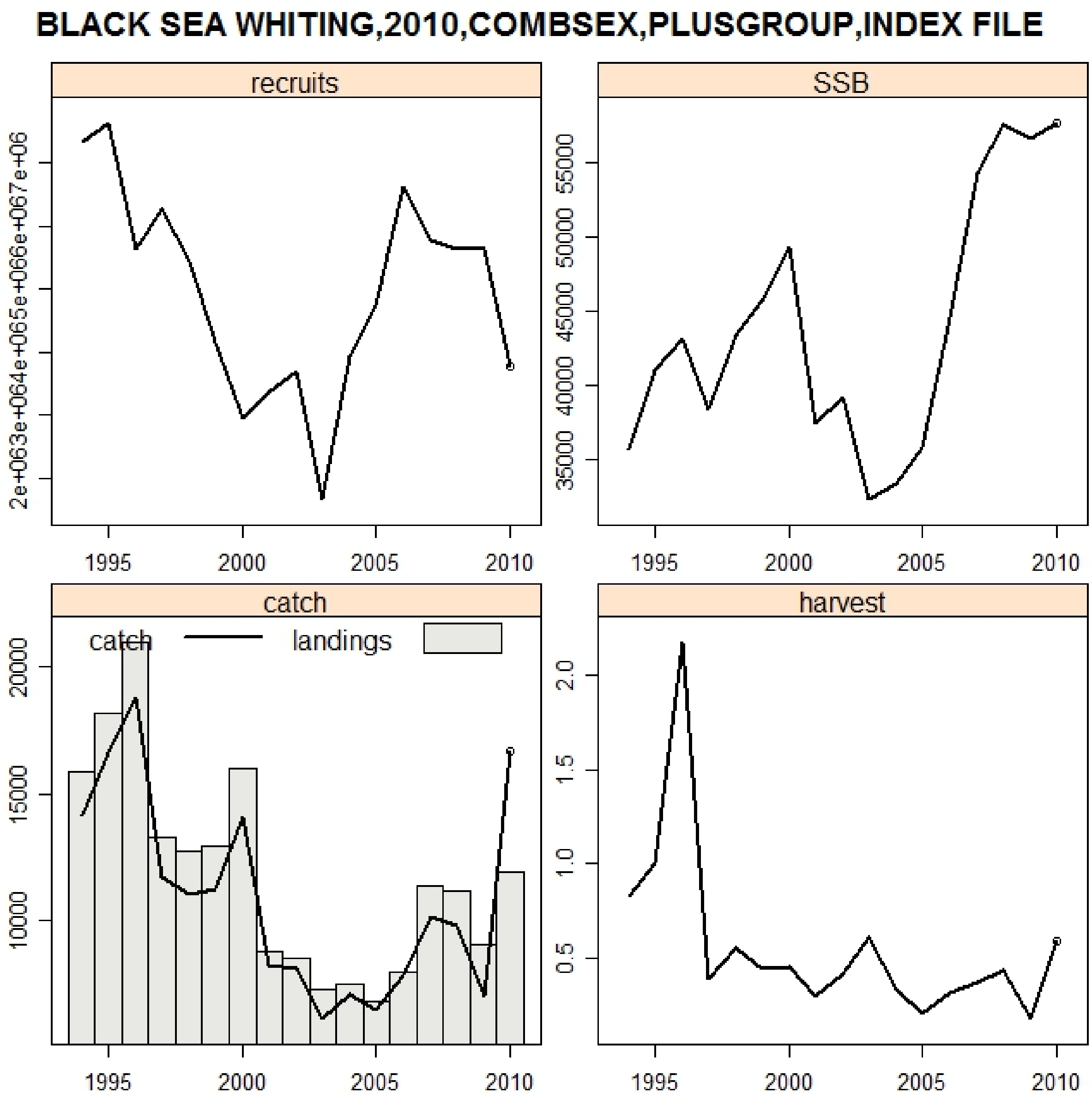


Fig. 6.4.4.1.3.2 Summary of trends in stock parameters as estimated by the XSA with low shrinkage (2.0). F is averaged over ages 1-4.

7.4.5 Short term prediction of stock biomass and catch

7.4.5.1 Justification

A deterministic short term projection of stock size and catch for 2011-13 under varying management options has been conducted. A status quo fishing has been assumed for 2011.

7.4.5.2 Input parameters

The input parameters are those obtained from the XSA with a short term geometric mean as recruitment estimates of 2011, 2012 and 2013.

7.4.5.3 Results

Table 6.4.5.3.1 Management option table for whiting in the Black Sea. Landins and SSB are given in tons.

Fscenario	Fmult	Landings_2011	Landings_2012	Landings_2013	SSB_2011	SSB_2012	SSB_2013	ChangeSSB_2011_2013	ChangeCatch_2012_2010
0.4	0.68	13663	8544	9995	48789	45304	47866	-1.9	-48.7
0	0	13663	0	0	48789	45304	58023	18.9	-100
0.06	0.1	13663	1493	2199	48789	45304	56210	15.2	-91
0.12	0.2	13663	2893	4081	48789	45304	54524	11.8	-82.6
0.18	0.3	13663	4208	5694	48789	45304	52952	8.5	-74.7
0.24	0.4	13663	5444	7076	48789	45304	51487	5.5	-67.3
0.29	0.5	13663	6608	8262	48789	45304	50118	2.7	-60.3
0.35	0.6	13663	7705	9280	48789	45304	48838	0.1	-53.7
0.41	0.7	13663	8740	10154	48789	45304	47640	-2.4	-47.5
0.47	0.8	13663	9718	10906	48789	45304	46517	-4.7	-41.7
0.53	0.9	13663	10643	11552	48789	45304	45463	-6.8	-36.1
0.59	1	13663	11520	12108	48789	45304	44472	-8.8	-30.8
0.65	1.1	13663	12352	12586	48789	45304	43539	-10.8	-25.8
0.71	1.2	13663	13142	12998	48789	45304	42660	-12.6	-21.1
0.76	1.3	13663	13893	13353	48789	45304	41831	-14.3	-16.6
0.82	1.4	13663	14608	13659	48789	45304	41048	-15.9	-12.3
0.88	1.5	13663	15289	13922	48789	45304	40306	-17.4	-8.2
0.94	1.6	13663	15940	14149	48789	45304	39604	-18.8	-4.3
1	1.7	13663	16561	14344	48789	45304	38938	-20.2	-0.6
1.06	1.8	13663	17155	14512	48789	45304	38306	-21.5	3
1.12	1.9	13663	17724	14656	48789	45304	37704	-22.7	6.4
1.18	2	13663	18270	14781	48789	45304	37132	-23.9	9.7

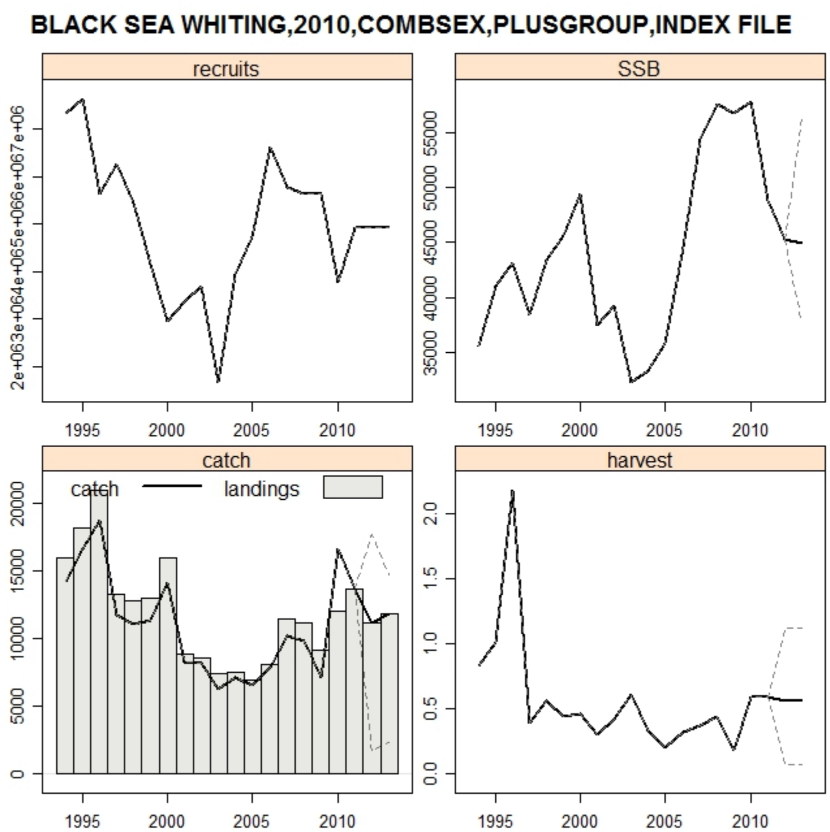


Fig. 6.4.5.3.1 Historic trends and short term prediction (status quo) of relevant stock parameters.

7.4.6 Medium term prediction of stock biomass and catch

The WG did not undertake medium term projections.

7.4.7 Long term predictions

7.4.7.1 Justification

A yield per recruit YpR analysis was conducted.

7.4.7.2 Input parameters

The input parameters are those averaged over the whole time series as obtained from the XSA based.

7.4.7.3 Results

```
An object of class "refpts":
        quantity
refpt    harvest   yield     rec       ssb       biomass   revenue   cost
  f0.1   0.4006200 0.0022381 1.0000000 0.0096937 0.0125222        NA        NA
  fmax   1.6644148 0.0025927 1.0000000 0.0044570 0.0072060        NA        NA
  spr.30 0.9433239 0.0025519 1.0000000 0.0061517 0.0089433        NA        NA
  msy    1.6644148 0.0025927 1.0000000 0.0044570 0.0072060        NA        NA
  mey           NA        NA        NA        NA        NA        NA        NA
```

The EWG proposes F0.1=0.4 as approximation of the Fmsy reference point consistent with high long term yields.

7.4.8 Scientific advice

7.4.8.1 Short term considerations

State of the spawning stock size:
Since 1994 the SSB has varied without a trend. In the absence of biological reference points the EWG 11-16 is unable to fully evaluate the stock status.

State of recruitment: Since 1994 the recruitment has varied without a trend. There is no fishery indepent recruitment index (survey) available as none of the surveys cover the entire stock area.

State of exploitation:
The EWG 11-16 proposes Fmsy(1-4)≤0.4 as limit reference point consistent with high long term yields and low risk of fisheries collapse. As the estimated F(1-4)=0.59 exceeds such reference point and thus the EWG 11-16 classifies the stock of whiting in the Black Sea as being subject to overfishing. The EWG 11-16 recommends a sustainable fishing in 2012 which implies a total catch of 8 500 tons not to be exceeded. The EWG 11-16 however notes the geographicaly uneven pattern in exploiting of this stock as evident by the distribution of the landings (Table 6.4.2.3.1.1.). Given that this is not a highly migratory species we may conclude that the resident population is much stonglier exploited in the southern part (Turkish waters) than in the rest of the Black Sea - an effect that has been demonstarted by Prodanov et al. (1997) who performed separate VPA analyses of the western/northern and eastern/southern components of the whiting stock.

7.4.8.2 Medium term considerations

Due to the lack of discard information in the catch statistics, which might bias the assessment, no medium term analyses have been conducted.

7.5 Horse mackerel in the Black Sea

7.5.1 Biological features

7.5.1.1 Stock Identification

The Black sea horse mackerel is a subspecies of the Mediterranean horse mackerel *Trachurus mediterraneus.* Although in the past the Black sea horse mackerel has been attributed to various subpopulations, in a more recent study Prodanov *et al.* (1997) brought evidence that the horse mackerel rather exists as a single population in the Black sea, and thus all Black sea horse mackerel fished across the region should be treated as a unit stock.

The horse mackerel is a migratory species distributed in the whole Black Sea (Ivanov and Beverton, 1985, Fig. 6.5.1.1.1). In the spring it migrates to the north for reproduction and feeding. In summer the horse mackerel is distributed preferably in the shelf waters above the seasonal thermocline. In the autumn it migrates towards the withering grounds along the Anatolian and Caucasian coasts migration (Ivanov and Beverton, 1985). The horse mackerel population in the Black Sea mainly winters along the Crimean, Caucasian and Anatolian coasts and warm sections of the Marmara Sea. They winter at a depth ranging between 20 and 90 meters off Crimea and between 20 and 60 meters off the Caucasian coasts. The horse mackerel population continuously remains in the eastern Black Sea winters in an area north-east of Trabzon. The population migrating between Marmara and the eastern Black Sea spend the winter in the Bosphorus area and off the Marmara Sea at optimal depths ranging between 30 and 50 meters. Depending on water temperature, feeding migration starts in mid-April or towards the end of that month (Demir, 1958). Horse mackerel groups migrate from the Bosphorus to the Bulgarian and Romanian coasts in the north. They are also believed to migrate from Crimea to the north-west and from the Caucasian and north-eastern Anatolian coasts to the Crimean coasts. Autumn migration starts in September and reaches a peak in October and November (Ivanov and Beverton, 1985).

The family Carangidae is represented by two species in the Black Sea: *Trachurus trachurus* and *T. mediterraneus* (Drenski, 1948, 1951; Aleev, 1956; Georgiev and Kolarov, 1959, 1962; Stoyanov *et al.,* 1963; Svetovidov, 1964; Valkanov *et al.,* 1978; Sivkov, 2004; Zhivkov *et al.,* 2005; Kapapetkova and Zhivkov, 2006; Raykov and Yankova, 2008; Yankova *et al.,* 2010a). The systematic position of the Black Sea horse mackerel was examined by Nümann (1956) and Aleev (1952, 1957). These authors stated that in the Black Sea the species is represented by four local subpopulations: a south western (Bosporic), a northern (Crimean), an eastern (Caucasian) and a southern (Anatolian). Each subpopulation has its own biological characteristics such as wintering grounds, fat content, spawning patterns, age composition, growth rate, feeding patterns.

According to some authors (Aleev, 1956; Georgiev and Kolarov, 1959, 1962; Stoyanov *et al.,* 1963; Kapapetkova and Zhivkov, 2006) the Black Sea horse mackerel is represented into two size-forms: ”large” and “small”. The presence of the large form has been reported for a first time in 1913 by S. A. Zernov (Aleev, 1956). However, after that time this form disappeared, but it is registered again in the territorial waters of Georgia in 1947 and is being intensively fished for 10 years. Draughts of the large form for the eastern part of the Black Sea reached up to 8601,7 t in 1954 (Tikhonov *et al.,* 1955). Since 1958, only single specimens are found in the nets (Dobrovolov, 2000). There are several hypotheses about the presence of the large horse mackerel in the Black Sea: a) it is a new immigrant from the Mediterranean (Aleev, 1956); b) it is the same small horse mackerel with accelerated growth under extremely favorable conditions (Tikhonov *et al.,* 1955; Shaverdov, 1964); c) it is an ecological breed that hibernates in the warmest areas (Aleev, 1957), or it is an ecotype (Shaverdov, 1964); d) it belongs to another species present in the Mediterranean or even in the Atlantic Ocean and in case of extremely high species numbers some shoals enter the Black Sea enlarging their nutritive territory (Altukhov and Salmenkova, 1981); e) it is a polyploid form of the small horse mackerel originating in the Black Sea (Georgiev and Kolarov, 1962); f) it is a "giant" horse mackerel as a new species *Trachurus gigas*, n.sp (Banarescu and Nalbant, 1979).

According to Shaverdov (1964), the "large" and "small" forms of the Black Sea horse mackerel belongs to one and the same subspecies as described by Aleev (1957). After the study of Golovko (1964) about the electrophoretic spectra of serum proteins from these two forms, Shulman and Kulikova (1966) reconsidered their own earlier assumption about the belonging of both forms to a taxonomically close but different species. Tkacheva (1957) performs crosses between small and large horse mackerel under field conditions on board a research motor boat, which showed the possibility to obtain hybrids. Until now, there does not exist any information confirming the polyploidity of the large form of horse mackerel. On the other hand, the existence of two different subspecies of *T. mediterraneus* in the Black Sea: *T. m.* ssp. *ponticus* and *T. m.* ssp. *mediterraneus* is described by Altukhov and Apekin (1963) based on serological analyses and also by Altukhov and Michalev (1964) by means of the characteristics of the cellular thermal (Prodanov *et al.,* 1997). According to (Dobrovolov & Dobrovolova 1983; Dobrovolov and Manolov 1983; Dobrovolov, 1988) no difference at species level can be found between *T. mediterraneus* ssp. *ponticus* and *T. mediterraneus* ssp. *mediterraneus* by electrophoretical method. Dobrovolov (1986) revealed that the occurrence of large form can be explained as a result of heterosis effect between the above-mentioned subspecies.

Turan (2004) analysed the population structure of *T. mediterraneus* in Turkish coastal waters using morphometric and meristic traits and reported on population structuring in three areas: the Black Sea, Marmara Sea and the north-east Mediterranean Sea. The samples from the Black Sea were similar to each other for both morphometric and meristic charactrers. Biometric indices were insufficient to distinguish two horse mackerel subpopulations in the Bulgarian and Turkish Black Sea waters (Yankova and Raykov, 2006a). The same authors concluded that all of the morphological differences are possible due to variability of the habitat and sample size of the study. Acording to Prodanov *et al.,* (1997) the Black Sea horse mackerel represent a single population, as the environmental conditions are almost one and the same in the whole area inhabited, and there exists no positive evidence for the occurrence of two distinct subpopulations differing substantially in their biological parameters. The present mtDNA analysis also indicated that there were no subspecies of *T. mediterraneus* from the Turkish Black Sea waters (Bektas and Belduz, 2008).

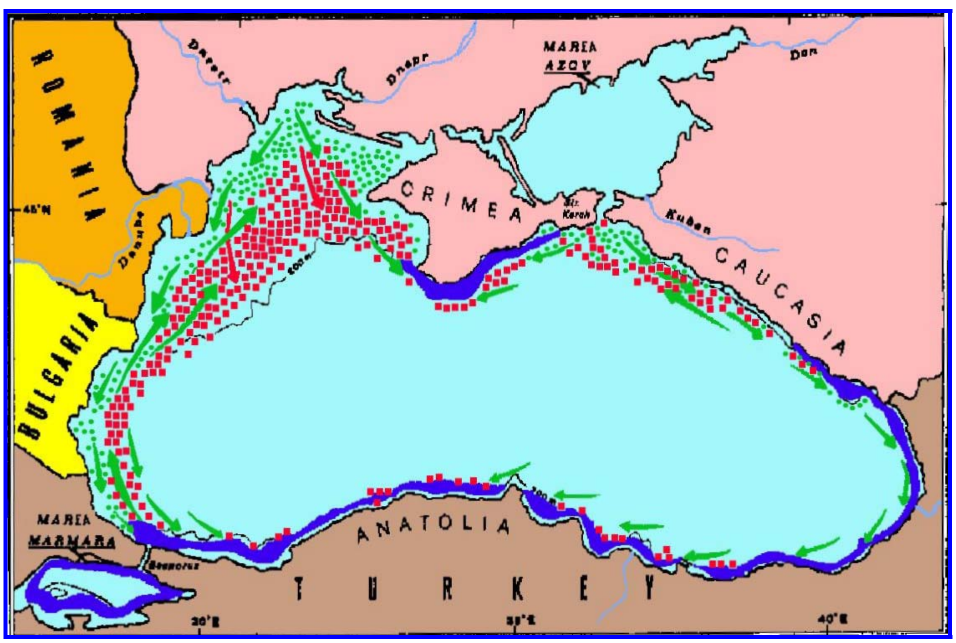


Fig.6.5.1.1.1 Distribution and migration routes of horse mackerel in the Black Sea.

7.5.1.2 Growth and maturity

Horse mackerel growth parameters from VBGF and length-weight relationship, provided by different countries are presented in Table 6.5.1.3.1.

The exponent *b* ranged between 3.3029 for females and 3.3123 for males, exhibiting positive allometric growth (Yankova *et al.,* 2010). There was not a significant difference when the length-weight relationships of the sexes were compared using covariance (P > 0.05). The slope (*b* value) of the length-weight relationship was similar for males (3.3123) and females (3.3029), indicating that weight increased allometrically with length (Yankova *et al.,* 2010).

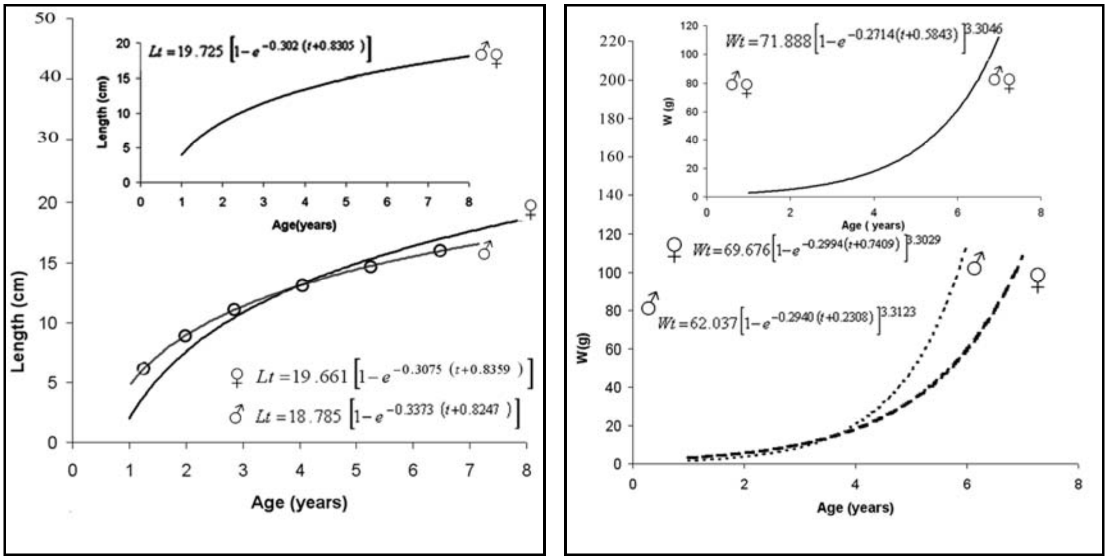


Figure 6.5.1.3.1. Length Weight growth curves of horse mackerel males, females and both sexes combined from Bulgarian Black Sea waters (after Yankova *et al.,* 2010).

Comparison of the growth parameters of horse mackerel in Bulgarian Black Sea waters (Yankova *et al.,* 2010) showed that there were no differences (ANOVA, F = 1.40, P > 0.05). During the first 3 years of life females and males differ in length (Figs. 6.5.1.3.1; 6.5.1.3.2). Males are characterized by higher growth rates than females (Yankova *et al.,* 2010).

Table 6.5.1.3.1. VBGF parameters calculated in the Black Sea

COUNTRY	YEAR_PERIOD	SPECIES	SEX	L_INF	K	t_0	a	b
Bulgaria	2007-2008	HMM	C	19.75	0.3020	-0.8305	0.0035	3.3046
Bulgaria	2007-2008	HMM	M	18.785	-0.3373	-0.8247	0.0034	3.3123
Bulgaria	2007-2008	HMM	F	19.661	-0.3075	-0.8359	0.0038	3.3029
Romania	2000	HMM	C	18.6	0.224	-1.43	0.0380	2.3552
Romania	2001	HMM	C	18.95	0.268	-0.63	0.0470	2.3501
Romania	2009	HMM	C	18.42	0.42	-0.41	0.0450	2.3469
Romania	2010	HMM	C	20.3	0.302	-0.467	0.0111	2.9065
Turkey	1991 - 1992	HMM	M	19.9	0.396	-1.02	0.0110	3.18
Turkey	1991 - 1992	HMM	F	20.6	0.356	-1.11	0.0080	2.993
Turkey *	2005	HMM	C	20.237	0.3181	-1.603	0.0081	2.9983
Turkey *	2006	HMM	C	22.394	0.241	-1.932	0.0064	3.0986
Turkey *	2007	HMM	C	22.232	0.2554	-1.828	0.0085	2.984
Turkey *	2008	HMM	C	22.244	0.2538	-1.8	0.0069	3.1018
Turkey *	2009	HMM	C	24.023	0.2082	-2.075	0.0062	3.1024
Turkey *	2010	HMM	C	25.002	0.187	-2.11	0.0052	3.1654
Ukraine	2008	HMM	C	18.5	0.343	-0.66	_	_

data according "Purse seine fisheries monitoring project by Trabzon Central Fisheries Institute"

Following the PROBIOM method by Caddy and Abella (1999) based on life history traits, the natural mortality was estimated M=0.4 for all ages.

7.5.1.3 Maturity

The horse mackerel matures at age of 1-2 years during the summer, which is also the main feeding and growth season. It spawns in the upper layers, mainly in the open part of the sea as well as near the coast (Arkhipov, 1993). Eggs and larvae are often found in areas with a low productivity and higher salinity (Arkhipov, 1993). Daskalov (1999) has found that horse mackerel recruitment is related to divergence and increased productivity of the sea. Peak spawning in the Bulgarian Black Sea Coast falls between June-August (Georgiev *et al.,* 1961; Georgiev and Kolarov, 1962; Georgiev *et al.,* 1962; Stoyanov *et al.,* 1963, Karapetkova and Zhivkov, 2006; Yankova and Raykov, 2009; Yankova, 2011). Spawning has been reported to occur 20 miles off the coast (Georgiev *et al.,* 1962). The pelagic eggs are 0.73-1.00 mm (Georgiev *et al.,* 1961; Georgiev *et al.,* 1962; Stoyanov *et al.,* 1963) and hatch after four days (Radu and Radu, 2008) at local temperatures 16-26 °C and salinity is 15.5-19‰ (Georgiev *et al.,* 1961; Georgiev *et al.,* 1962; Stoyanov *et al.,* 1963). The eggs of horse mackerel are pelagic, spherical, with a drop of fat (Karapetkova and Zhivkov, 2006).

The horse mackerel reproduction start at age of 1 year during the summer in Southern Black Sea (peak July), reproduction temperature is between 18-25 °C , salinity salinity is 16-18 ‰ (Genc *et al.,* 1999).

7.5.2 Fisheries

7.5.2.1 General description

The horse mackerel (*Trachurus mediterraneus*) fishery operates mainly on the wintering grounds in the southern Black Sea using purse seine and mid-water trawls. The horse mackerel of age 1-3 years generally prevails in the commercial catches, but strong year classes (for example, the 1969-year class) may enter into exploitation at age of 0.5 year and may prevail up to age 5-6 years. Over the last 40 years, highest horse mackerel catches were reported in the years preceding *M. leidyi* outbreak (1988-1990). (Prodanov *et al*., 1997; FAO, 2007). The maximum catch of 141 thousand tons was recorded in 1985, from which ~100 thousand tons were caught by Turkey (Prodanov *et al*., 1997). In the next four years catches remained at the level of 97-105 thousand tons. In the period 1971-1989, the stock increased, although years of high abundance alternated with years of low abundance due to year class's fluctuations, typical of this fish. VPA estimates showed that the stock was highest in 1984-1988 (Prodanov *et al*., 1997). Scientists (Chashchin, 1998) believed that the intensive fishing in Turkish waters in 1985-1989 has led to overfishing of horse mackerel population and reduction of the stock and catches in the next years. A drastic decline in stock abundance occurred after 1990 when the stock diminished by 56%. In 1991 the horse mackerel stock dropped to a minimum of 75 thousand tons and the catch dropped to 4.7 thousand tons that is a twenty fold reduction compared to the average annual catch in 1985-1989.

The horse mackerel recruitment has been highly variable with the stock biomass supported by sporadic strong year-classes (e.g. 1969, 1983, 1987) followed by weak-ones. Thus, the influence of a strong year-class can be traced through the subsequent few years of biomass increase. No evidence of reliable stock-recruitment relationship has been found (Daskalov, 1999). The relationship with selected environmental variables has been explored by Daskalov (1999, 2003). A strong negative correlation was with surface temperature (SST) has been found. It may appear surprising for a warm-water summer spawning species to correlate negatively with SST. Such relationships have been also found however in other studies (Simonov et al., 1992). The effect of the wind stress was significant and generally positive. These results indicate that horse mackerel recruitment has been more abundant in years with increased physical forcing and enrichment, probably related to the spawning distribution wide spread over areas of low productivity.

During 1985-1993, only in 1988 a relatively successful recruitment was recorded. Despite of its coincidence with the first year of *M. leidyi* outbreak, the juveniles from this cohort were sufficiently well supplied with food. As the first burst of *M. leidyi* occurred in the autumn of 1988, the summer zooplankton maximum production did not suffer much from the devastating effect of *M. leidyi*. The copepods *Oithona nana* and *Oithona similis*, constituting the main food of larval horse mackerel (Revina, 1964), were especially abundant. However, the favorable trophic conditions for larvae in summer 1988 failed to ensure the formation of numerically strong year-class because further in the year juveniles were faced with strong feeding competition with *M. leidyi*. Sharp decline in *Oithona* under the predation pressure of *M. leidyi* in the subsequent years (Vinogradov *et al*., 1993 ;) affected the survival of horse mackerel. Dietary studies of juvenile and adult horse mackerel (Revina, 1964) have shown that both the habitat diet of juvenile horse mackerel and *M. leidyi* overlap, therefore the strong feeding pressure by *M. leidyi* on zooplankton directly affected larval and juvenile horse mackerel. Food in relation to fish size shows that the most important for the diet of horse mackerel groups are *Mysidacea* and *Pisces.* The contribution of the rest of groups was relatively low (Yankova & Raykov, 2010). The same authors reveal that main prey of the Black Sea horse mackerel is fish and zooplankton. This group represents over 55% of the total IRI and was the main food for this species. Besides having the largest number of zooplankton, it had a high impact on populations of commercial fish such as sprat and anchovy.

Over the last 40 years, highest horse mackerel catches were reported in the years preceding *M. leidyi* outbreak (1988-1990). Quantitative stock assessments showed that the stock was highest in 1984-1988, although years of high abundance alternated with years of low abundance due to year classes' fluctuations, typical of this species. Scientists believed that the intensive fishing in Turkish waters in 1985-1989 has led to over fishing of horse mackerel population and reduction of the stock and catches in the next years. A drastic decline in the stock abundance occurred after 1990 when the stock diminished by 56%. In 1991 the horse mackerel stock dropped to a minimum of 75 thousand tons and the catch dropped to 4.7 thousand tons, hat is a twenty fold reduction compared to the average annual catch in 1985-1989. In contrast to anchovy and sprat, the horse mackerel stock still remains in a depressed state. The total catch (taken predominantly by Turkey) in 2000-2005, remains ~10 th. t, similar to the pre-industrial period 1950-1975.

The catches of Black sea horse mackerel were realized by active (bathypelagic trawls and surrounding nets) and passive fishing gears (gill netting, trawl net, trap nets) (Prodanov *et al.,* 1997; Yankova *et al.,* 2010a). The Bulgarian and Romanian catches are taken primarily by passive, while the Turkish and former USSR entities by active gears (Prodanov *et al.,* 1997). The horse mackerel of age 1-3 years generally prevails in the commercial catches (Grishin *et al.,* 2007; Yankova and Raykov, 2009; Yankova *et al.,* 2010a), but strong year classes (for example, the 1969 year class) may enter into exploitation at age of 0.5 year and may prevail up to age 5-6 years (Grishin et al., 2007). The accuracy of the stock assessments depends exclusively on the fishery statistical data (Prodanov *et al.,* 1997). There are lack of information on horse mackerel catches or its underestimation by Russia, Ukraine and Georgia, Romania and Bulgaria enhances the risk of an incorrect assessment of biomasses. Over the last 40 years, highest horse mackerel catches were reported in the years preceding *Mnemiopsis leidyi* outbreak (1988-1990) (Prodanov *et al.,* 1997). The improvements of fishing gears and the application of modern echo-acoustics further contribute to a more effective fishery (Prodanov *et al.,* 1997). The same authors reported that when the level of the horse mackerel stock was low, even small catches caused higher fishing mortality, and vice verse. All this stresses the necessity of annual assessments of stock size, of TAC`s, as well as of clarifying the causes (natural and anthropogenic) determining flictuations in year class strength.

7.5.2.1.1 State of the fisheries in Turkey

Horse mackerel stock was a subject of overfishing, resulting in a fisheries collapse in the beginning of 1990's (Ozekinei et al., 2001). The ratios of undersized individuals for horse mackerel were 89% and 92% for autumn and winter seasons, respectively. The corresponding ratios for the horse mackerel for the same seasons were 70 and 67%, respectively. Minimum allowable sizes for horse mackerel and bluefish are 13 and 20cm, respectively. The 50% cumulative values obtained trawling trials are close to those figures. But the ratios of the undersize fish of horse mackerel (< 13 cm) for the seasons of spring, autumn and winter were calculated as 93.7, 75.8 and 30.7%, respectively (Dincer *et al*., 2007).

Production of the horse mackerel, which is the second most important pelagic catch along Turkey's Black Sea coasts after the European anchovy, steadily increased until the mid-1980s and reached its maximum level of approximately 100,000 tons in 1985. The total amount of catch, however, constantly declined due to uncontrolled fishing activities and over-fishing in the 1990s and declined to 80,000 tons. Research into commercial fish stocks on Turkey's Black Sea coasts conducted during the second half of the 1980s indicated that the horse mackerel population suffered the greatest fall in terms of quantity after the sea-perch among the pelagic stocks in the past 15 years (Bingel *et a*l., 1995; Zengin *et al*., 1998a; Zengin, 2001). The breakdown of horse mackerel caught by commercial fishermen between 1991 and 1993, when the amount of horse mackerel catch started to decrease along Turkish coasts, by length confirms this conclusion. The average lengths of horse mackerel caught by large purse-seine nets and trawlers during those years were 11.1 cm, 10.9 cm and 10.6 cm, respectively (Zengin, 1998). Average operating ratio (E) calculated for the same period was 0.78 (Genc *et al*., 1999), which clearly demonstrates the over-fishing of the horse mackerel stock. This sharp fall in the horse mackerel catch steadily increased until the end of the 1990s. The share of horse mackerel below optimal catch length (L_{opt}.= 13 cm) in the total catch caught by coastal surrounding nets in the eastern Black Sea early in the 1990s (1990-1993) was 52.2%, rose towards the end of 1990s (66.7 %) (Zengin *et al*., 1998a, Zengin *et al*., 2002) – Table 6.5.2.1.1.1. The length of the horse mackerel population off the southern Black Sea coast after they reach initial reproductive maturity is 11.7 cm (Genc *et al*., 1999). A large part of immature and young individuals below the optimal catch length (*discards catch*) are taken by coastal fishermen from stock and sold on the market under the counter or destroyed on the sea. In order to eliminate this trend, which is an indicator of growth over-fishing, new fishing methods and management planning are also considered necessary for horse mackerel populations.

After the beginning of the 2000s the landings started to increased again. Total Turkish Black sea catch was up to 26.000 tons (2006 official statistics) and the average length also increased 13.7 cm. (Genç *et al*, 2006).

Horse mackerel stocks in the Black Sea are usually caught by Turkish fishermen by using active (bottom trawler, pelagic trawler and large bag-shaped nets) and passive (extension and longline) nets Table 4.4.2.2. Almost the whole horse mackerel catch (98.2%) is caught by large bag-shaped nets. CPUE of fishing boats using that type of net for catching horse mackerel is 3837.5 (600-10,000) kg/boat/day (Zengin *et al*., 2003). The remaining part of the catch is caught by bottom trawler, pelagic trawler, extension net and long lines. A large part of the catch (80%) is caught in the autumn and the first part of winter (September-December) (Zengin *et al.,* 1998a) (Fig. 6.5.2.1.1.1).

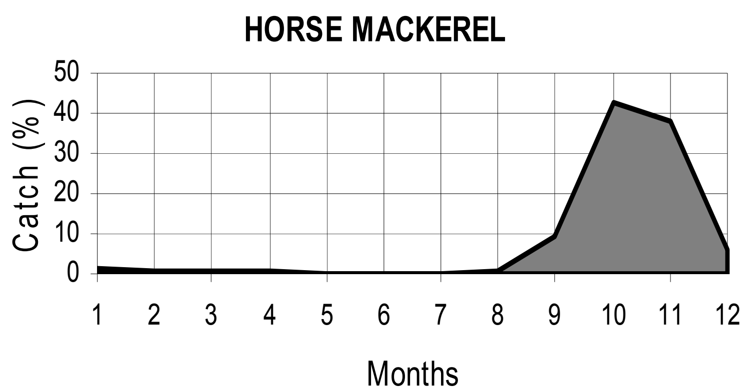


Figure 6.5.2.1.1.1. Catch distribution of the Horse mackerel in the south Black Sea by monthly.

Table 6.5.2.1.1.1. Distribution of average length (cm) and catches below the optimum catch length (L_{opt}) in the southern Black Sea in the period between 1990 and 2010.

Fishing season	**Landings (tons)**	**Optimum catch length (cm)**	**Mean weight(g)**
1990	75882	11.1	
1991	25679	10.9	
1992	20989	10.1	
1993	23945	-	
1994	25275	-	
1995	15809	-	
1996	16093	-	
1997	11097	-	
1998	8246	-	
1999	8331	-	
2000	16181	12.4	
2001	16750	-	
2002	8903	-	
2003	9213	-	
2004	9113	13.1	
2005	17003	11.6	15.70
2006	25927	12.7	17.69
2007	17429	12.6	16.71
2008	20124	13.2	20.57
2009	15905	12.6	17.09
2010	12929	12.1	17.00

Table 6.5.2.1.1.2. % catch and catch per unit effort according to type of net in the south Black Sea in the period of between 1990 and 2000

Fish species	Parameters	Purse seine	Trawl	Pelagic trawl	Gill-nets	Set-net	Long-line
Horse mackerel	%Catch CPUE (kg/boat/day)	98.2 3837.5 (600-10000)	0.3 -	0.4 2038.7 (95.9-79.20)	0.9 -	-	0.2 -

7.5.2.1.2 State of the fisheries in Ukraine

After a long absence, since the end of 2002 was renewed fishing of horse mackerel in the waters under the jurisdiction of Ukraine. Horse mackerel forms aggregations during the wintering and to a lesser extent, in the autumn on migration routes. The Ukrainian waters near the Southern coast of Crimea from November to March it occur wintering ground of horse mackerel. In the formation of wintering aggregations of horse mackerel it possible for fishing by lifting cone-shaped nets with electric light attraction, and purse seines. In the warm season in small quantities horse mackerel harvested with pound nets, including the Sea of Azov. In recent years the number of horse mackerel midwater trawl is produced as by-catch in fisheries sprat. Generally, the share of Ukrainian total catch in the catch of mackerel in the Black Sea is very low.

7.5.2.2 Management regulations applicable in 2010 and 2011

The EWG 11-16 will provide a full description of national and international regulations regulating the horse mackerel fisheries during its next meeting in 2012.

7.5.2.3 Catches

7.5.2.3.1 Landings

The data of Bulgarian catches show considerable fluctuations, they could be distinguished in two stages(Yankova *et al*.,2009). In the first stage from 2000 to 2003 years, relatively high amounts of catches are evident. In 1992 was realized catch of 165 t. Last relatively high catch amount of 141.6 t was reported in 2003. Upon 1993 the amounts of catches suddenly dropped particularly in 1994-1999 period, when the landings fluctuated from 30 t in 1999 to 80 t in 1994. The last investigated years are characterized by a trend of considerable increase of horse mackerel catches. Comparison with 2007 substantially increase (round about 55%) was reported in catches of horse mackerel, which is the amount was 179.8 t for 2008 (data source -official statistics of the National Agency of Fisheries and Aquaculture). The data set of landings was compiled for the period 1992 – 2010 (Tabl. 6.5.2.3.1.1).

Table 6.5.2.3.1.1. Horse mackerel landings by countries (FAO Fisheries Statistics, GFCM Capture Production 1992 – 2006, 2007 – 2010 from National Fisheries Statistics of countries).

Year	**Bulgaria**	**Georgia**	**Romania**	**Russian Federation**	**Turkey**	**Ukraine**	**Total**
1992	54	0	22	0	20989	0	21065.00
1993	31	0	30	0	23945	0	24006.00
1994	80	0	35	1	25275	1	25392.00
1995	70	0	24	1	15809	2	15906.00
1996	68	0	10	0	16093	0	16171.00
1997	36	18	1	0	11097	5	11157.00
1998	40	13	15	2	8246	0	8316.00
1999	30	0	3	2	8331	1	8367.20
2000	111	35	8	2	16181	0	16336.80
2001	130	7	17	6	16750	1	16911.00
2002	141.5	19	21	28	8903	34	9146.50
2003	141.6	70	10	77	9213	745	10256.60
2004	73.9	56	14	105	9113	272	9633.90
2005	29.4	60	12	169	17003	329	17602.40
2006	62.834	55	19	200.5	12812	476	13625.33
2007	115.88	53	14	63.2	17429	211	17886.08
2008	179.607	8	11	154.24	20124	366	20842.85
2009	176.91	6*	17	124.04	15905*	260	16489.06
2010	165.27	5*	7	108.86	12929*	190	13405.50

* expert assessments

In 1992 was achieved a catch of 21065 t. Upon 1994 the amounts of catches decreased especially in 1998-1999 period. In 2008 considerably increase in catches of horse mackerel was reported, at the level of 20842.85 t (Figure 6.5.2.3.1.1).

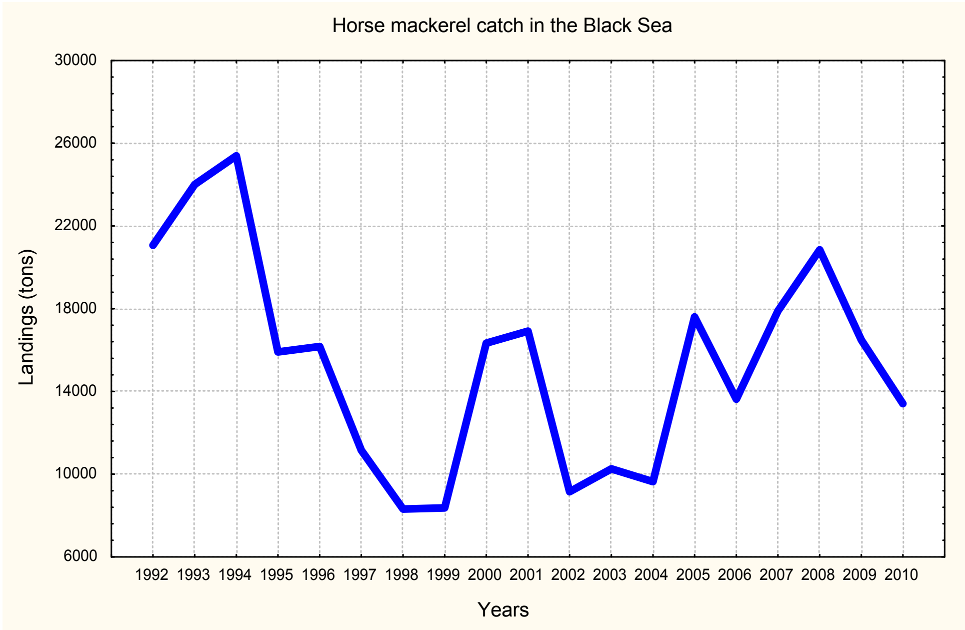


Figure 6.5.2.3.1.1 Trend in total horse mackerel landings in the Black Sea.

7.5.2.3.2 Discards

No discards have been reported for the horse mackerel fishery.

7.5.2.4 Fishing effort

No information has been tabled during the EWG 11-16 meeting

7.5.2.5 Commercial CPUE

Table 6.5.2.5.1. CPUE kg/h of horse mackerel by fishing gears in Bulgaria, 2008-2010.

Mediterranean horse mackerel HMM			2008	2009	2010
	FPO	LOA>0<6	344.98	101.56	51.22
		LOA=>6<12	130.4	97.62	77.67
		LOA=>12<18	209.73	43.33	-
	OTM	LOA=>6<12	149.8	95.54	105.28
		LOA=>12<18	273.78	112.44	202.42
		LOA=>18<24	456.47	294.84	321.25
		LOA=>24<40	268.4	279.61	293.23

Legend: FPO –Pound nets/Pots; OTM – Midwater otter trawl; LOA – Length overall of the fishing vessels.

Table 6.5.2.5.2. Average CPUE kg/h of horse mackerel in Bulgaria, 2008-2009.

Fleet Segment	LOA>0<6		LOA=>6<12		LOA=>12<18		LOA=>18<24		LOA=>24<40	
Average CPUE	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Mediterranean horse mackerel HMM	94.74	36.98	92.99	49.12	258.88	65.02	458.73	308.69	262.79	282.17

7.5.3 Scientific Surveys

No specific fisheries independent scientific surveys have been conducted.

7.5.4 Assessment of historic parameters

7.5.4.1 Method 1: Separable VPA with varying terminal Fs (0.4, 0.8 and 1.2)

7.5.4.1.1 Justification

STECF SG BLACK SEA 10-02 found out that data available in different national databases would allow performing a quantitative assessment of this stock. Data from the Turkish fisheries (~95% of the catch) will be very important but horse mackerel fisheries are quite important for rest of the Black Sea countries especially when the stock is high that assures a regular strong migration in the northern Black Sea. Fisheries and biological (age and individual size and growth) and survey data (acoustics, juveniles, and egg-production) from all countries need to be thoroughly compiled.

At the first stage data must be carefully screened and organised into age structured matrices. Age structured assessment methods such as VPA (XSA) and ICA than can be applied similar to sprat and turbot.

The lack of any tuning series to estimate terminal fishing mortalies in 2010, the EWG 11-16 decided to run 3 versions of separable VPAs with F=0.4, F=0.8 and F=1.2 as arbitrary inputs, respectively. This tange has been chosen after a review of the results obtained from the Jones method (Table 6.5.4.1.1.1).

Table 6.5.4.1.1.1. Horse mackerel fishing mortality (F) by Jones method (Ukrainian waters).

	Year					
FL, mm	2004	2005	2006	2007	2008	2009
146-150	0.243	1.340	1.826	0.532	1.194	0.499
151-155	0.280	1.049	2.099	0.624	0.638	0.373
156-160	0.342	1.177	0.843	0.637	0.547	0.357
161-165	0.463	0.479	0.463	0.742	0.903	0.186

Following the PROBIOM method by Caddy and Abella (1999) based on life history traits, the natural mortality was estimated M=0.4 for all ages.

Table 6.5.4.1.1.1. Data availability by countries.

Type of data	Turkey	Romania	Bulgaria	Ukraine	Comment
Catch (monthly, quarterly, yearly)	yes	yes, Monthly, 2006-08	The end year 2008	The end year 2010	
IUU catches	Only can be estimated	no	The end year 2008	no	Expert est.: low level (not more then 10-15%)
Fishing gears	yes	yes	The end year 2008	yes	Trawls (by-catch), Lift cone-shaped nets with electric light attraction, Pound nets
Fishing seasons	yes	yes	The end year 2008	yes	Trawls: November-March; Lift cone-shaped nets: December-February; Pound nets: June-September
Fishing areas	yes	yes	The end year 2008	yes	Trawls & Lift cone-shaped nets: Crimean waters; Pound nets: Crimean&NW of Black Sea coastal waters, Crimean of Azov Sea coastal waters
Fishing and natural mortality estimations	yes	yes	no	2004-2009	
Mean individual weights	yes	yes	The end year 2008	2009	2003-2008
Catch-at-age	yes	yes		2004-2010	
Length and weight at age	yes	yes	yes	2010	
CPUE from commercial yield and surveys	Indirectly		no	no	
Migration routes (spawning,fattening,wintering grounds)	Indirectly	yes	yes	yes	
Existing fishery regulations in country	yes	yes	yes	yes	
Existing analyses for 1950-2009	Some years; 1990-93	yes	yes	yes	In Turkey; they are some poulation parametrs diffrent yeras, diffrent area and institution

7.5.4.1.2 Input parameters

Table 6.5.4.1.2.1. Aggregated Catch at age in number 10^{-3} of Bulgaria, Georgia, Romania, Russia Turkey and Ukraine.

Age Year	0	1	2	3	4	5	6
2004	4004	8496.3	23719.55	348640.9	486.8653	170.3481	20.41601
2005	24623.8	442576.7	504480.7	115439.6	15402.4	2078.61	54.25074
2006	7149.718	274253.2	378853.8	64652.91	19545.35	2295.039	554.5081
2007	596.9276	631119.2	363755.2	59751.05	5692.716	2740.416	0
2008	6601.745	187904.2	551534.8	231373.6	27245.18	2556.786	26.64733
2009	3910.733	395249.7	420001.4	88190.1	35478.36	5780.068	998.3546
2010	28037.68	300250.7	334447.1	129098	57226.42	18832.02	6057.423

Table 6.5.4.1.2.2. Weight at age in the catch and stock (in gr.).

Age Year	0	1	2	3	4	5	6	Mean
2004	8.61	12.51	14.15	25.86	30.58	39.46	43.41	24.99
2005	4.24	13.23	20.62	29.72	38.62	45.84	43.56	15.93
2006	4.94	14.28	21.30	31.79	42.23	51.82	57.20	18.23
2007	9.66	14.70	20.10	29.19	36.97	42.72		16.82
2008	4.79	12.66	23.07	30.28	39.00	50.90	41.25	20.69
2009	5.19	13.01	20.69	30.22	42.54	50.12	67.44	17.36
2010	4.37	10.05	21.85	28.46	31.43	36.81	63.36	15.34

Table 6.5.4.1.2.3. Horse mackerel maturity at age.

Age Year	0	1	2	3	4	5	6
2004	0	0.8	1	1	1	1	1
2005	0	0.8	1	1	1	1	1
2006	0	0.8	1	1	1	1	1
2007	0	0.8	1	1	1	1	1
2008	0	0.8	1	1	1	1	1
2009	0	0.8	1	1	1	1	1
2010	0	0.8	1	1	1	1	1

7.5.4.1.3 Results

The following results are derived from the separable VPA based on a terminal F=0.4.

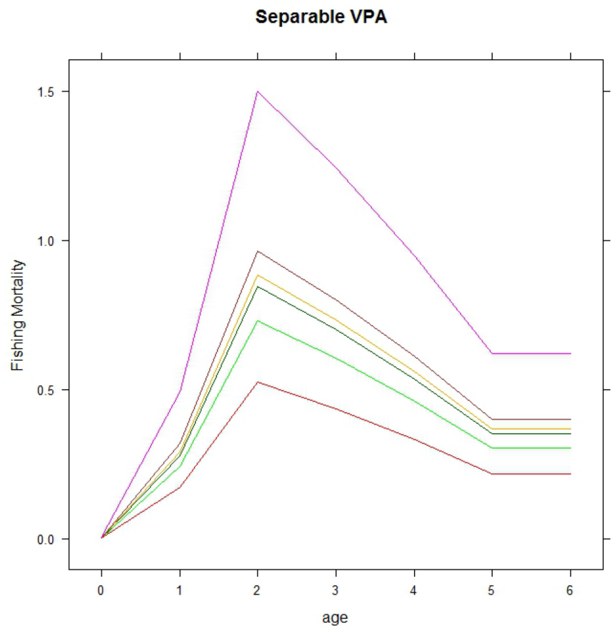


Figure 6.5.4.1.3.1.1 Selection patterns as derived from the separable VPA with F=0.4 as terminal F.

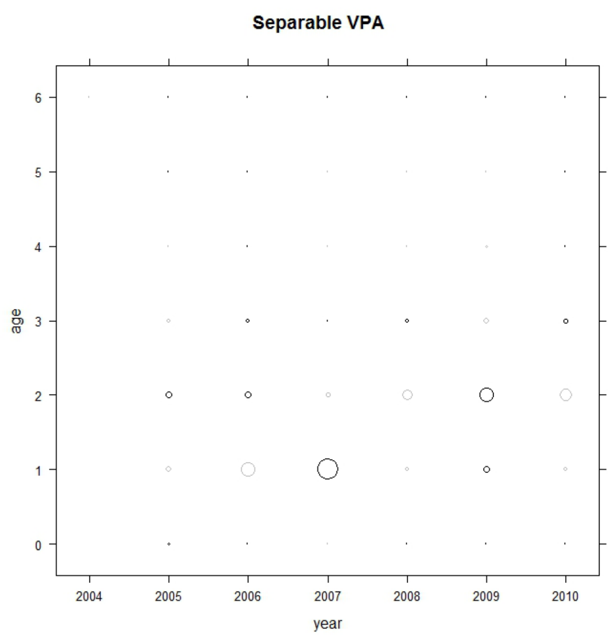


Figure 6.5.4.1.3.1.2 Residuals in estimated fishing mortalies.

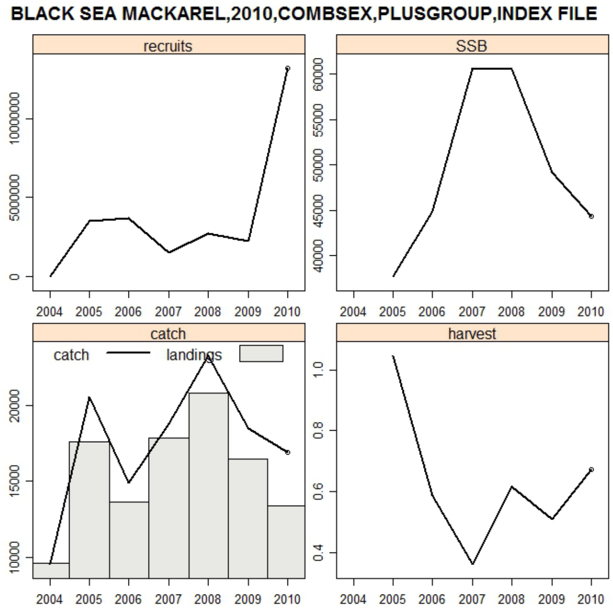


Figure 6.5.4.1.3.1.3 Time-series of horse mackerel population estimates of total stock in the Black Sea (FLR for Quantitative Fisheries Stock Assessment Analysis with terminal F =0.4): A. recruitment (line) and stock spawning biomass (SSB); B. landings (grey) and catch (line).

The following results are derived from the separable VPA based on a terminal F=0.8.

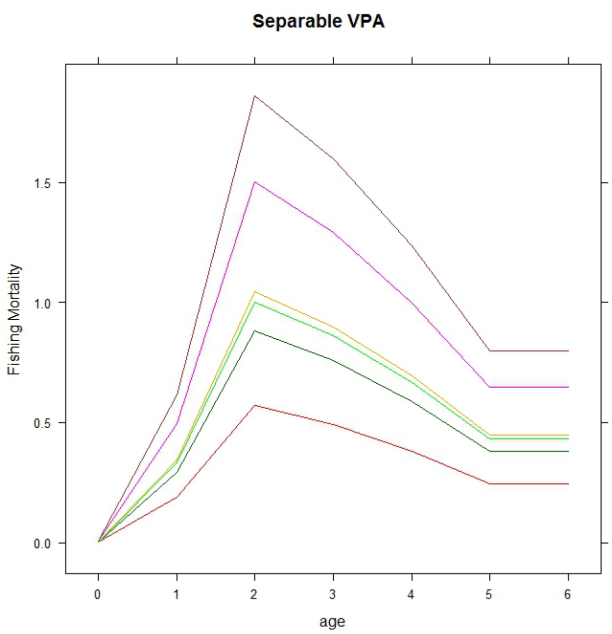


Figure 6.5.4.1.3.1.4 Selection patterns as derived from the separable VPA with F=0.8 as terminal F.

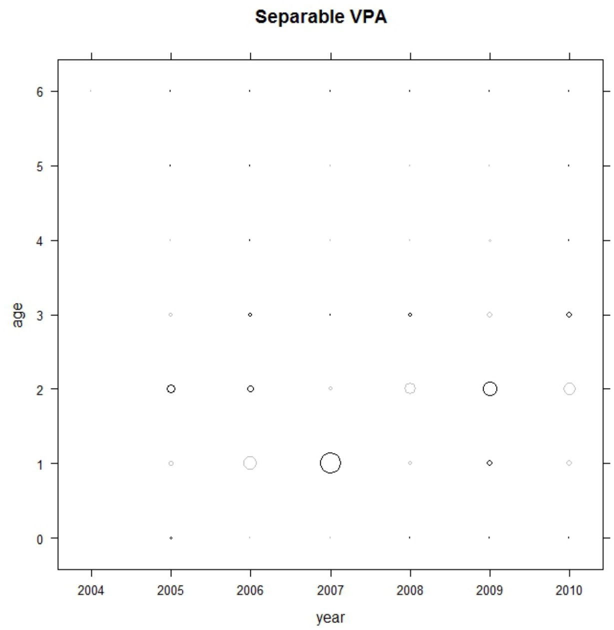


Figure 6.5.4.1.3.1.5 Residuals in estimated fishing mortalies.

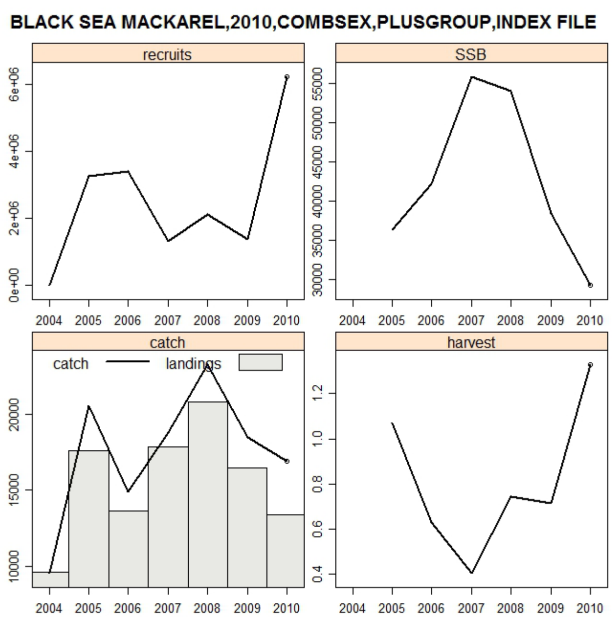


Figure 6.5.4.1.3.1.6 Time-series of horse mackerel population estimates of total stock in the Black Sea (FLR for Quantitative Fisheries Stock Assessment Analysis with terminal F =0.8): A. recruitment (line) and stock spawning biomass (SSB); B. landings (grey) and catch (line).

The following results are derived from the separable VPA based on a terminal F=1.2.

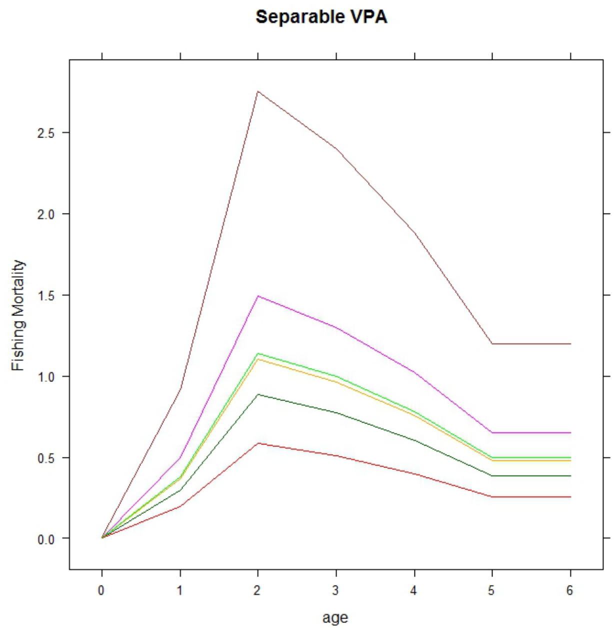


Figure 6.5.4.1.3.1.7 Selection patterns as derived from the separable VPA with F=1.2 as terminal F.

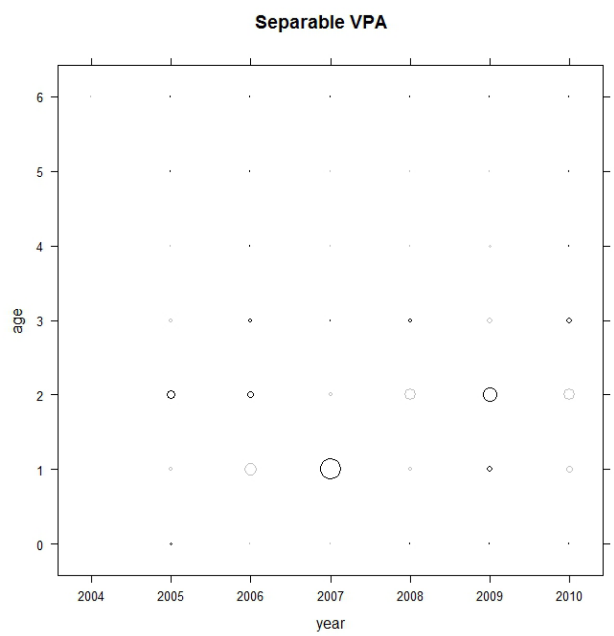


Figure 6.5.4.1.3.1.8 Residuals in estimated fishing mortalies.

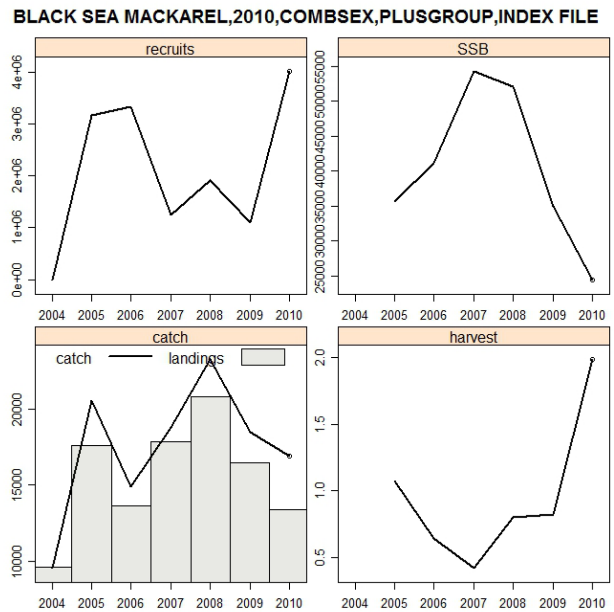


Figure 6.5.4.1.3.1.6 Time-series of horse mackerel population estimates of total stock in the Black Sea (FLR for Quantitative Fisheries Stock Assessment Analysis with terminal F =1.2): A. recruitment (line) and stock spawning biomass (SSB); B. landings (grey) and catch (line).

The following tables summarizes all estimated trajectories of the stock parameters of all three scenarions considered.

Table 6.5.4.1.3.1.1 Stock parameters of 3 separable VPA scenarios, (F=0.4, F=0.8 and F=1.2), SSB and landings in tons, recruitment R in thousands.

Year	SSB	R	F	Landings	
2004				9633.9	
2005	37754	3503593	1.04554	17602.4	**F=0.4**
2006	44866	3705772	0.59026	13625.33	
2007	60680	1500324	0.36512	17886.08	
2008	60606	2730272	0.61668	20842.85	
2009	49239	2194065	0.50969	16489.06	
2010	44361	13206063	0.67295	13405.5	
Year	**SSB**	**R**	**F**	**Landings**	
2004				9633.9	
2005	36378	3269500	1.07272	17602.4	**F=0.8**
2006	42208	3416658	0.62974	13625.33	
2007	55846	1307859	0.40783	17886.08	
2008	54009	2102241	0.74503	20842.85	
2009	38349	1369494	0.71608	16489.06	
2010	29302	6244820	1.32927	13405.5	
Year	**SSB**	**R**	**F**	**Landings**	
2004				9633.9	
2005	35723	3173891	1.07638	17602.4	**F=1.2**
2006	41197	3329170	0.6402	13625.33	
2007	54292	1252966	0.42204	17886.08	
2008	52047	1905232	0.79687	20842.85	
2009	35029	1093149	0.82309	16489.06	
2010	24508	4022171	1.98612	13405.5	

7.5.5 Short term prediction of stock biomass and catch

The current state of the assessment does not allow any reliable formulation of a short term prediction of stock size and biomass under various management scenarios.

7.5.6 Medium term prediction of stock biomass and catch

The current state of the assessment does not allow any reliable formulation of a medium term prediction of stock size and biomass under various management scenarios.

7.5.7 Long term predictions

The current state of the assessment does not allow any reliable formulation of a long term prediction of stock size and biomass to conclude on biological reference points consistent with high long term yields.

7.5.8 Scientific advice

The lack of a fishery independent scientific survey to monitor horse mackerel all over the Black Sea to indicate trends in total mortality and recruitment appears the major data deficiency in the assessment. EWG 11-16 recommends such survey to be established.

7.5.8.1 Short term considerations

State of the spawning stock size:
The assessment is considered only indicative of relative stock trends. All three assessment formulations indicate that the SSB in 2010 is reduced from a higher level. In the absence of total stock size estimates and biological reference points, EWG 11-16 is unable to fully evaluate the stock size with regard to the precautionary approach.

State of recruitment:
Recruitment is indicated to have varied without a clear trend since 2004.

State of exploitation:
Given the current state of the assessment of horse mackerel in the Black Sea, EWG 11-16 is unable to provide a biological reference point consistent with high long term yield nor to quantify the expoitation rate. Based on the assessment results the exploitation rate appears to have varied since 2004 without a clear trend. In the absence of a biological reference points, EWG 11-16 is unable to fully evaluate the exploitation state with regard to the precautionary approach.

7.5.8.2 Medium term considerations

Given the current state of the assessment of horse mackerel in the Black Sea, EWG 11-16 is unable to provide advice for the medium term future.

7.6 Piked Dogfish in the Black Sea

7.6.1 Biological features

7.6.1.1 Stock Identification

Piked dogfish inhabits the whole Black Sea shelf at the water temperatures 6 – 15º C – Fig. 6.6.1.1.1 and Fig. 6.6.1.1.2 It undertakes extensive migrations. In autumn feeding migrations are aimed at the grounds of the formation of the wintering concentrations of anchovy and horse mackerel in the vicinity of the Crimean, Caucasus and Anatolian coasts. With their disintegration picked dogfish disperses all over the shelf. Reproductive migrations of viviparous picked dogfish take place towards the coastal shallows with two peaks of intensity – in spring and autumn. The autumn migration for reproduction covers more individuals usually. The major grounds for reproduction of picked dogfish in the Ukrainian waters are located in Karkinitsky Bay, in front of Kerch Strait and in Feodosia Bay.

Piked dogfish belongs to long-living and viviparous fish; therefore reproduction process includes copulation and birth of fries. Near the coasts of Bulgaria, Georgia, Romania, Russian Federation and Ukraine the intense spawning season is in March-May. Two peaks of birth of juveniles can be distinguished – spring period (April-May) and summer-autumn (August-September, Serobaba et al., 1988). To give birth of juveniles the females approach the coastal zone in depth 10 – 30 m (Maklakova, Taranenko, 1974). At this time males keep separately from females in depth 30 – 50 m. The birth of picked dogfish juveniles takes place at the temperature of water 12 – 18°C.

In autumn piked dogfish aggregates into large schools, accompanying anchovy and horse mackerel, which migrate to wintering grounds along eastern and western coast. During wintering the densest concentrations of picked dogfish are observed, where picked dogfish feeds intensively. They are associated, above all, with major wintering areas of anchovy in the waters of Georgia and Turkey. In the northwestern Black Sea in the waters of Ukraine and Romania in depth from 70-80 m down to 100-120 m abundant wintering concentrations of picked dogfish are also observed, where they are located on the grounds of whiting and sprat concentrations (Kirnosova, Lushnicova, 1990).

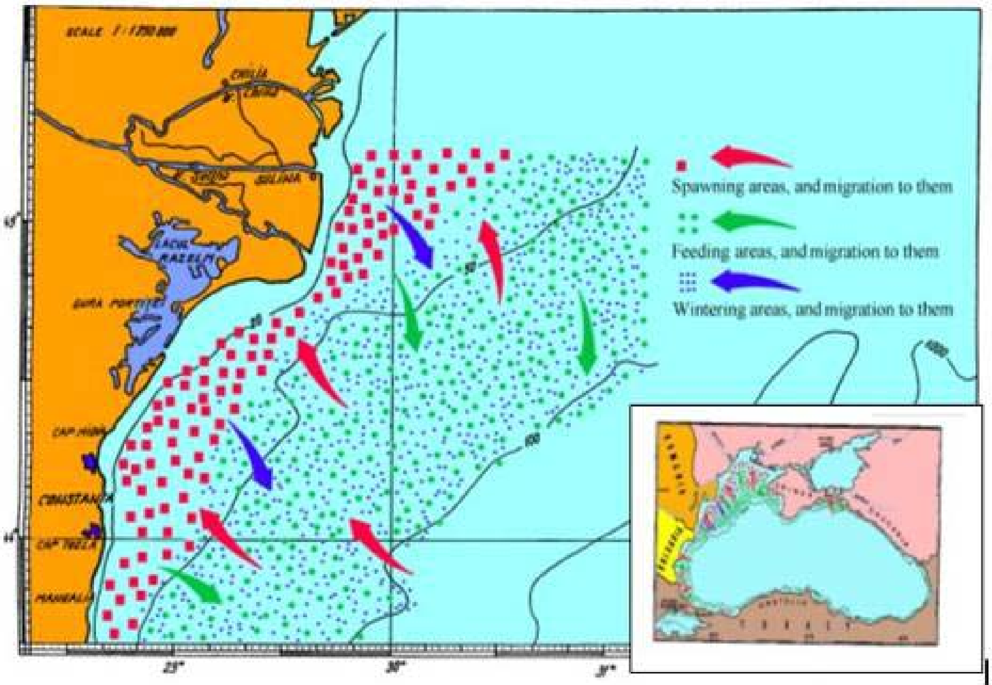


Fig. 6.6.1.1.1 Distribution and migration routes of the piked dogfish at Romanian littoral (Radu et al.,2009b, 2010a).

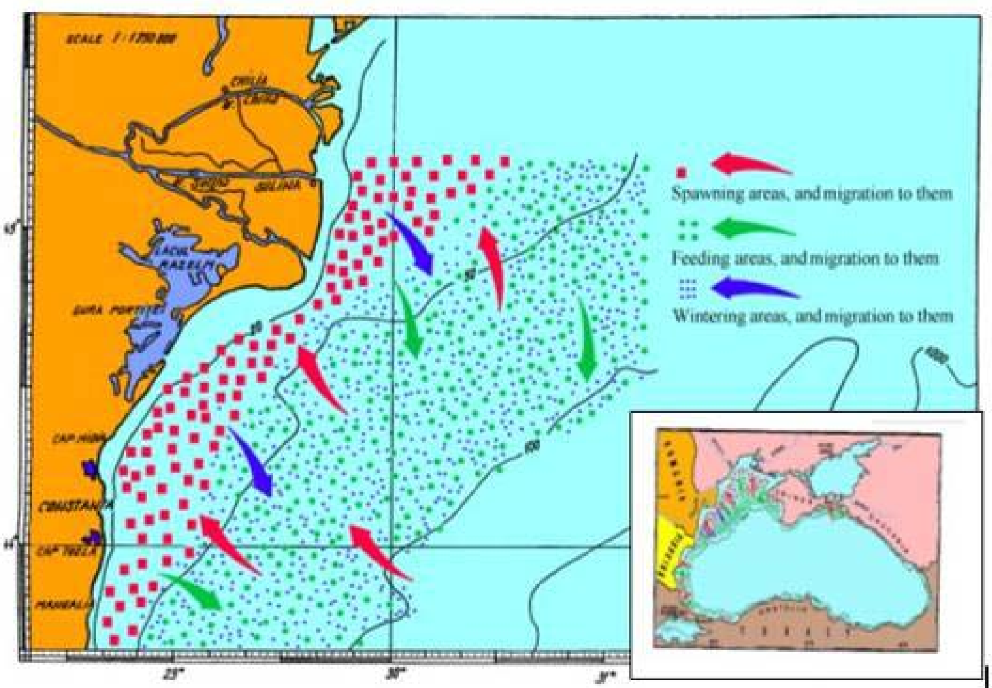


Fig. 6.6.1.1.2 Distribution and migration routes of the piked dogfish at Black Sea level.

7.6.1.2 Growth

Piked dogfish is a major demersal predator, reaching the Black Sea the length of about 1.50 m. According to investigations conducted in former USSR waters, Kirnosova, (1993) found that the piked dogfish maximum age is 20 years. The parameters in VBGF and natural mortality parameters are:

<u>Males:</u> K=0.029 t_0=-3.84; L_∞=272 cm; W_∞=47 kg; M=0.20÷0.23

<u>Females:</u> K=0.026 t_0=-3.32; L_∞=303 cm; W_∞=196 kg; M=0.15÷0.20

Age and length, at which 50% of individuals are mature, are 10.49 years and 87.57 cm for males and 11.99 years and 102.97 cm for females, respectively. Mean biennial fecundity is 19.4 eggs and 12.9 pups. The linear relationship between fecundity and length is: F_e = 0.09 x TLp + 2.12 (r = 0.5) for pups and F_o = 0.27 x T Lp - 21.59 (r = 0.7) for eggs (Demirhan and Seyhan, 2007).

7.6.1.3 Maturity

Life-history parameters and food diet of picked dogfish (*Squalus acanthias*) from the SE Black Sea were studied (Demirhan and Seyhan, 2007). Picked dogfish at age 1 to 14 years old were observed, with dominance of 8 years old individuals for both sexes. The length–weight relationship was $W=0.0040*L^{2.95}$and the mean annual linear and somatic growth rates were 7.2 cm and 540.1 g, respectively. The estimated parameters in VBGF were: W_∞=12021 (g), L_∞=157 (cm), K=0.12 ($year^{-1}$) and t_0=−1.30 (year). The size at first maturity was 82 cm for males and 88 cm for females. Mean biennial fecundity was also found to be 8 pups per female. The relationships fecundity–length, fecundity–weight and fecundity–age were found to be:

F=−17.0842+0.2369*L (r=0.93)

F=0.3780+0.0018*W (r=0.89)

F =−0.7859+1.1609*A (r=0.94), respectively.

7.6.2 Fisheries

7.6.2.1 General description

In the Black Sea the largest catches of piked dogfish are along the coasts of Turkey, although this fish is not a target species of fisheries, being yielded as by-catch in trawl and purse seine operations mainly in the wintering period. In the 1989-1995 annual catches of Turkey are 1055-4558 t (Shlyakhov, Daskalov, 2008). In subsequent years, they have decreased about 2 times and did not exceed 2400 t. In the waters of Ukraine most of piked dogfish is harvested in spring and autumn months by target fishing with gill-nets of 100 mm mesh-size, long-lines, and as by-catch of sprat trawl fisheries. As in Turkish waters, in the last 20 years the maximum annual catches of picked dogfish are observed in 1989-1995, reaching 1200-1300 t. After 1994 the catches went down being between 20 and 200 t. In the rest of countries piked dogfish is harvested mainly as by-catch, annual catches are usually lower than the Ukraine. The maximum annual catches of picked dogfish in 1989-2005 were: Bulgaria - 126 t (2001), Georgia - 550 t (1998), Romania - 52 t (1992), Russian Federation - 183 t (1990). It should be noted that in the waters of Bulgaria, the highest catches were observed in the early 2000's. In Romania dogfish is caught mainly as by-catch of the sprat trawl fishery. The catches decreased very much because of decreasing of the trawling effort (Maximov et al., 2008b, 2010b; Radu et al., 2009b, 2010a,b).

In Turkey piked dogfish lost its commercial importance in recent years. In the last 20 years, the decrease of dogfish landing may be may be due to over-fishing (Demirhan , phD thesis,)

7.6.2.2 Management regulations applicable in 2010 and 2011

The STECF EWG 11-16 will accomplish a description of relevant measures regarding piked dogfish fisheries during its next meeting in 2012.

7.6.2.3 Catches

7.6.2.3.1 Landings

The landings of Piked dogfish by countries are given on Table 6.6.2.3.1.1.

Table 6.6.2.3.1.1. Piked dogfish landings by countries (FAO Fisheries Statistics, GFCM Capture Production 2006 - 2008)

Year	Bulgaria	Georgia	Romania	Russian Federation	Turkey	Ukraine
1989	28	217	30	135	4558	1191
1990	16	128	45	183	1059	1330
1991	21	18	26	67	2017	775
1992	15	14	52	15	2220	595
1993	12	131	6	5	1055	409
1994	12	45	2	11	2432	148
1995	80	31	7	90	1562	67
1996	64	71	-	19	1748	44
1997	40	1	-	9	1510	20
1998	28	550	-	6	855	38
1999	25	18	-	9	1478	94
2000	102	21	-	12	2390	71
2001	126	27	-	27	576	134
2002	100	65	-	19	316	97
2003	51.3	40	-	29	1840	172
2004	47.2	31	-	34	111	93
2005	14.5	35	-	19	102	75
2006	6.226	10	9	17	193	67
2007	23.98	2	17	28	91	45
2008	22.75	-	10	59	35	79
2009	9.46	-	4	14	156	47
2010	-	-	3	8.5	16	27

7.6.2.3.2 Discards

Discarding may play a major role in the catch of piked dogfish. However, the EWG 11-16 has no quantitative information.

7.6.2.4 Fishing effort

The EWG 11-16 has no quantitative information.

7.6.2.5 Commercial CPUE

The EWG 11-16 has no quantitative information.

7.6.3 Scientific Surveys

7.6.3.1 Method 1: International and national surveys

The following section describes results of various fisheries independent scientific surveys.

7.6.3.1.1 Geographical distribution patterns

In Romanian waters the agglomerations are distributed on the entire shelf , but especially at depth deeper than 20m. Two peaks of intense spawning and of birth of juveniles are in spring and autum period at Romanian littoral.

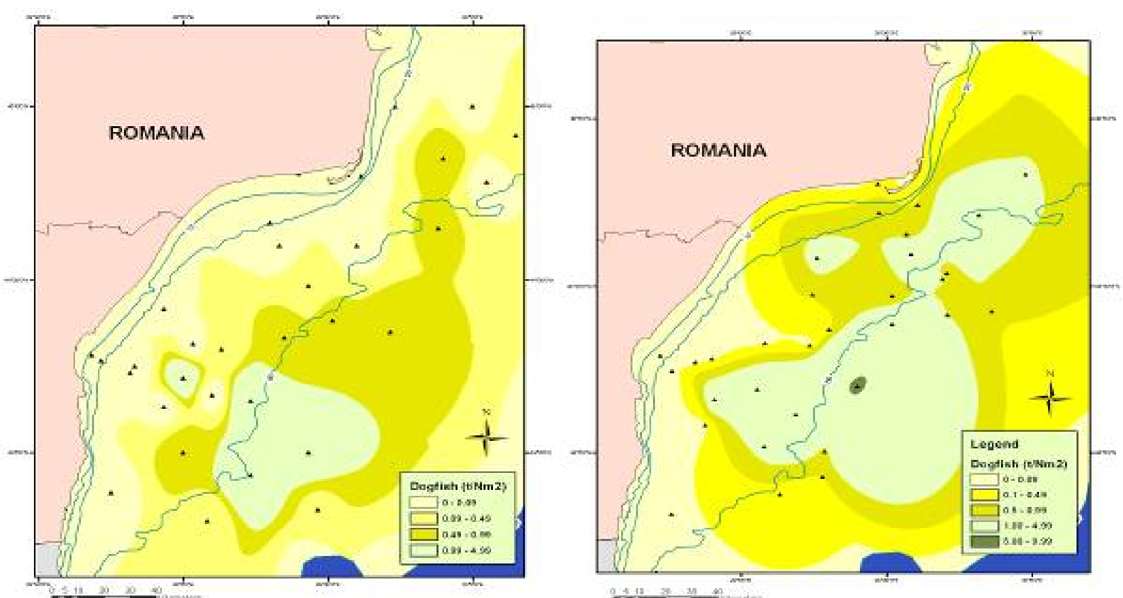


Fig. 6.6.3.1.1.1. Distribution of picked dogfish agglomeration during demersal trawl survey in May 2009 and 2010, Romanian Black Sea area.

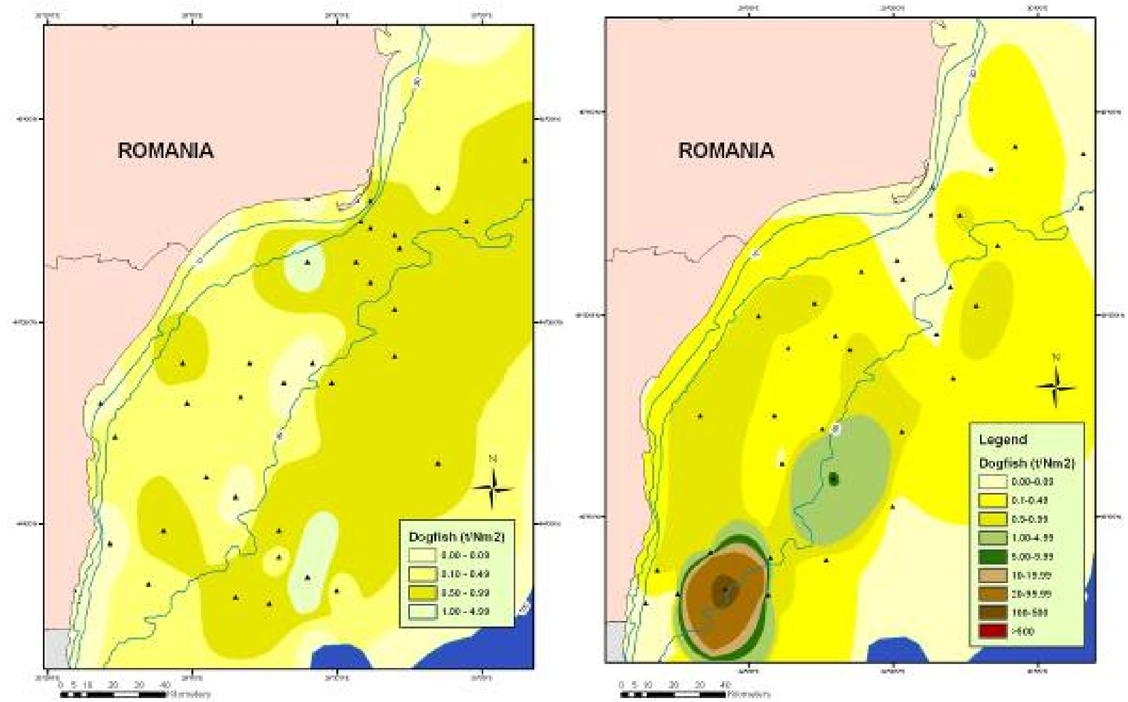


Fig. 6.6.3.1.1.2. Distribution of piked dogfish catches during demersal trawl survey in November 2009 and 2010 Romanian Black Sea area.

7.6.3.1.2 Trends in abundance and biomass

In the former USSR and later in Ukraine, to assess the piked dogfish stock, the swept area technique using bottom trawl surveys, as well as dynamic model of an isolated population, were applied (Shlyakhov, 1997). The abundance and biomass of picked dogfish in the waters adjacent to Georgia, the Russian Federation and Ukraine were assessed. Whole population of picked dogfish in 1972 – 1992 was assessed by VPA (Prodanov *et al.*, 1997, Daskalov 1998). The obtained results from stock assessments in 1989 – 2005 are given in Table 6.6.3.1.2.1. According to the assessments, in 1989 – 2005 the stock of picked dogfish in the shelf area of the Black Sea and in Ukraine waters tends to be gradually reduced. Observed dynamics of stock corresponds with increasing CPUE in Turkish waters.

Table 6.6.3.1.2.1. Commercial stock of picked dogfish in the Black Sea and along the coast of the former USSR and in the water of Ukraine, th. tones.

Years	Whole Black Sea shelf	Waters of Ukraine, the Russian Federation and Georgia		Waters of Ukraine	
	VPA	Trawl survey	Modeling	Trawl survey	Modeling
1989	117.8	58.5	63.5	34.6	-
1990	112.9	58.7	63.2	48.8	-
1991	97.9	17.2/69.9*	64.0	14.4/58.5*	-
1992	90.0	62.9	60.3	56.9	-
1993	-	-	57.1	30.2	-
1994	-	-	52.9	36.0	42.1
1995	-	-	-	-	37.6
1996	-	-	-	-	32.1
1997	-	-	-	-	31.0
1998	-	-	-	32.0	30.8
1999	-	-	-	-	28.0
2000	-	-	-	-	24.3
2001	-	-	-	-	22.3
2002	-	-	-	-	21.0
2003	-	-	-	-	22.1
2004	-	-	-	-	22.3
2005	-	-	-	-	21.0

* stock assessment is reduced to the average area of the registration (survey) zone.

According to the assessments of Prodanov *et al.* (1997) and Daskalov (1998) picked dogfish stock has increased until 1981, after that it began to decrease. The authors explained the increase in picked dogfish with the increased abundance of main food species (whiting, sprat, anchovy and horse mackerel), and its subsequent reduction partially with intensification of the dogfish fishery during the period 1979 – 1984.

In Romanian waters the swept area method was applied for stock assessment of piked dogfish. Results for estimated piked dogfish biomasses in May and November of 2009 in Romanian waters are given on 6.6.3.1.2.2 and Table 6.6.3.1.2.3 and Figures 6.6.3.1.2.1-2 (Maximov et al.2010b,c; Radu et al. 2009 a,b, 2010a,b). In May 2009 the biomass of dogfish was evaluated at 741 t, extrapolated to 967 t for the shelf till 50 Nm from the shore. In May 2010 the biomass of dogfish was evaluated at 2437 t, extrapolated to 5635 t for the shelf till 50 Nm from the shore. In the autumn period the biomass agglomeration increased at 2541 t (2009) and 13051 tons (2010).

Table 6.6.3.1.2.2 Assessment of piked dogfish biomass in May 2009 by demersal trawl, Romanian Black Sea area.

No. polygon	Surveyed area (Nm^2)	Range (t/Nm^2)	Average (t/Nm^2)	Total t in polygon (t)	Notes
1	1,227.13	0.00	0.00	0.0	Extrapolated at 967 t for the shelf till 50 Nm from shore
2	242.25	0.27 – 0.43	0.35	84.78	
3	165.00	0.23 – 0.28	0.26	42.90	
4	116.00	0.28	0.28	32.48	
5	724.25	0.53 0.76	0.63	456.27	
6	478.25	0.23 – 0.28	0.26	124.35	
7	265.63	0.00	0.0	0.00	
Total	3,218.5			740.78	

Table 6.6.3.1.2.3 Assessment of dogfish agglomeration in the Romanian area in the period May –June 2010, sampling gear demersal trawl

No. polygon	Polygon area (Nm^2)	Range (t/Nm^2)	Average (t/Nm^2)	Total tons in polygon (t)	Total on the shelf (t)
1	630.50	0.00	0.00	0.00	Extrapolated at 5635 tons for the shelf till 50 Nm from shore (about 5000 Nm2), including the new area (near Snake Island)
2	567.75	0.21-1.41	0.63	357.68	
3	216.75	0.24-0.68	0.47	101.87	
4	1155.00	0.56-5.62	2.11	2437.00	
Total	2570			2897.00	

Table 6.6.3.1.2.4. Assessment of picked dogfish biomass by demersal trawl in November 2009, Romanian Black Sea area.

No. polygon	Surveyed area (Nm^2)	Range (t/Nm^2)	Average (t/Nm^2)	Total t in polygon (t)	Notes
1	926.25	0.26 – 0.81	0.41	379.76	Extrapolated at 2,541 t for the shelf till 50 Nm from shore
2	2,404.13	0.39 – 2.04	0.68	1,634.81	
Total	3,330			2,015	

Table 6.6.3.1.2.4 Assessment of dogfish agglomeration in the Romanian area in the period October –November 2010, sampling gear demersal trawl

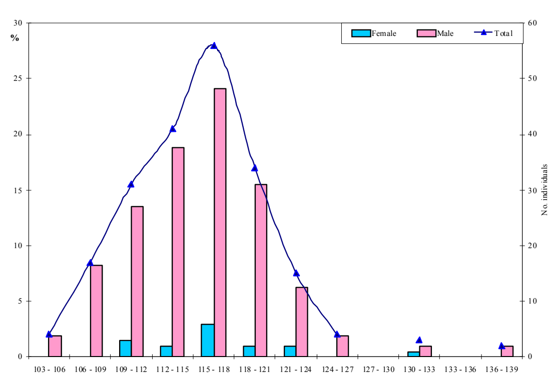
No. polygon	Polygon area (Nm^2)	Range (t/Nm^2)	Average (t/Nm^2)	Total tons in polygon (t)	Total on the shelf (t)
1	40	164.48	164.48	6579.2	Extrapolated at 13051 tons for the shelf till 50 Nm from shore (about 5000 Nm2), including the new area (near Snake Island)
2	56	5.82	5.82	325.9	
3	1201	0.00-0.89	0.46	552.5	
4	315	0.00	0.00	0.00	
5	570	0.00	0.00	0.00	
6	868	0.28-1.01	0.58	503.44	
TOTAL	3050			7961.04	

7.6.3.1.3 Trends in abundance at length or age

Table 6.6.3.1.3.1 Indices of abundance at length of the piked dogfish over the Romanian littoral

	2008		2009		2010	
class (cm)	%	Abundance (thousands)	%	Abundance (thousands)	%	Abundance (thousands)
89.5					1.00	17.62072219
92.5					0.00	0
95.5					2.00	35.24144438
98.5					2.99	52.86216657
101.5					0.00	0
104.5	2.28	2.86822019	1.93	7.60112077	0.50	8.810361095
107.5	1.51	1.90361497	8.21	32.3343013	7.98	140.9657775
110.5	6.82	8.59549206	14.98	58.9973001	16.46	290.7419161
113.5	17.42	21.9609092	19.81	78.0197941	23.44	414.0869715
116.5	28.04	35.3431352	27.05	106.533843	17.71	312.7678189
119.5	16.67	21.014259	16.43	64.7079867	9.73	171.8020414
122.5	14.39	18.1395444	7.24	28.5140489	4.49	79.29324986
125.5	6.82	8.59778419	1.93	7.60112077	2.99	52.86216657
128.5	2.27	2.86172582	0	0	8.73	154.1813192
131.5	2.27	2.86172582	1.45	5.71068659	2.00	35.24144438
134.5	1.52	1.9162217	0	0	0.00	0
137.5	0	0	0.97	3.82025241	0.00	0
Total	100.00	126.062633		393.840455		1766.4774

The population data of picked dogfish at the Romanian Black Sea area are given in the figures bellow – Length frequency data - Figs. 6.6.3.1.3.1, Fig. 6.6.3.1.3.2, Fig. 6.6.3.1.3.3, 6.6.3.1.3.4 (Maximov et al.,2010a,c; Radu et al., 2010a).



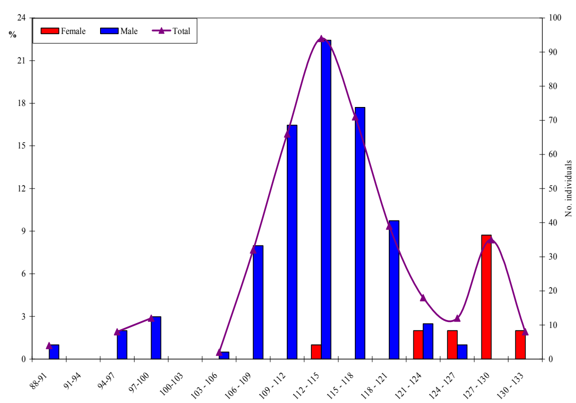
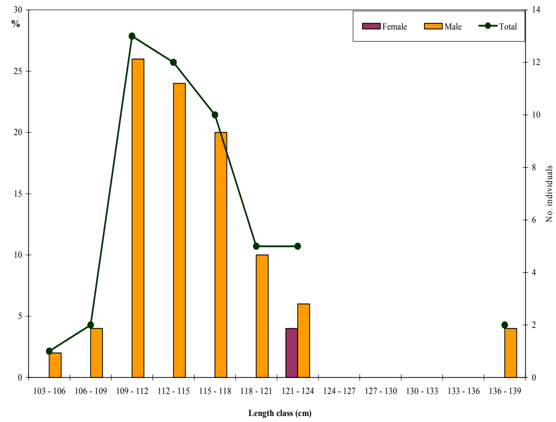


Fig. 6.6.3.1.3.1 Length frequency of piked dogfish in 2009 and in 2010, Romanian Black Sea area.



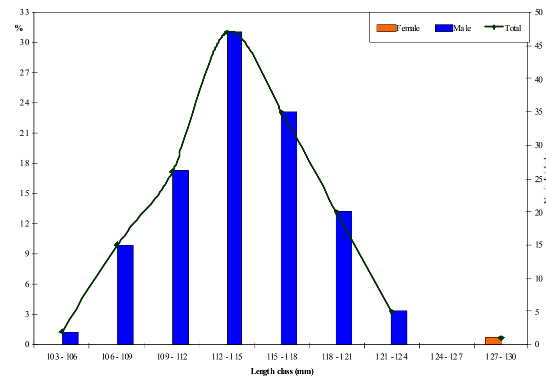
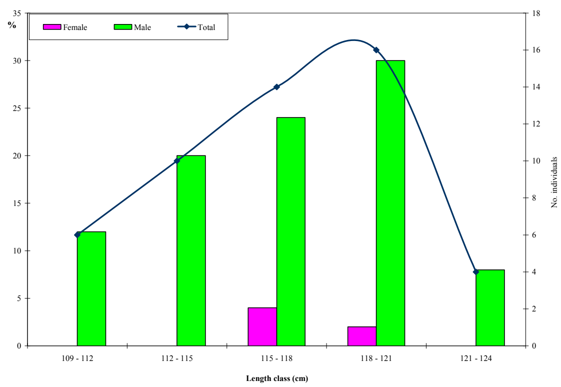


Fig. 6.6.3.1.3.2 Length frequency of piked dogfish in May 2009, in May 2010 at Romanian marine area.



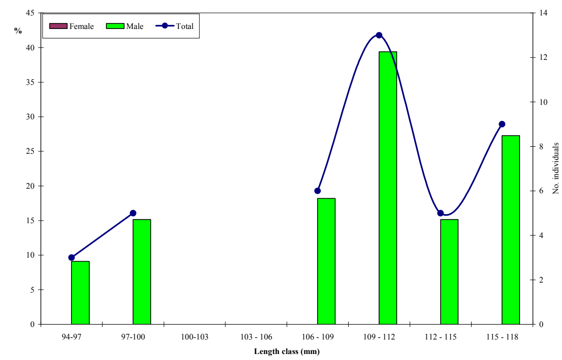
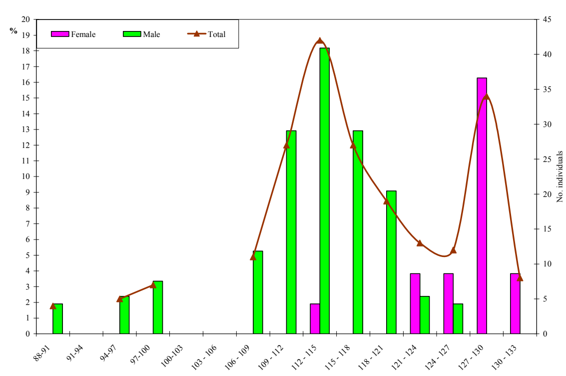


Fig. 6.6.3.1.3.3 Length frequency of piked dogfish in June 2009 and in June 2010 at Romanian marine area.



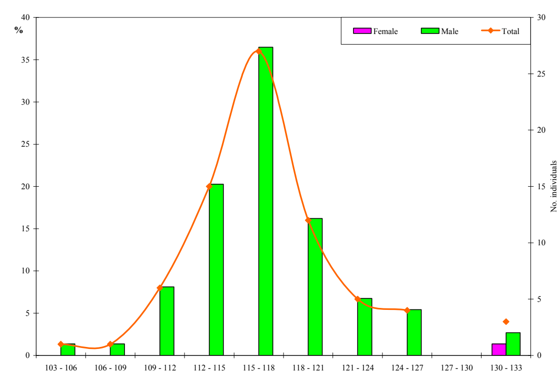


Fig. 6.6.3.1.3.4 Length frequency of piked dogfish in November 2009 and in November 2010.

6.6.3.1.3.2 Romanian catches in number of individuals on length classes

		Catches in number of individualas and tons per length classes						
Year	Catches (t)		2008		2009		2010	
2008	10.283	class (cm)	%	Abundance	%	Abundance	%	Abundance
2009	4.27	89.5					1.00	4
2010	3.069	92.5					0.00	0
		95.5					2.00	8
year	Abundance(No.individuals)	98.5					2.99	12
2008	1468	101.5					0.00	0
2009	670	104.5	2.28	33	1.93	13	0.50	2
2010	415	107.5	1.51	22	8.21	55	7.98	33
		110.5	6.82	100	14.98	100	16.46	68
		113.5	17.42	256	19.81	133	23.44	97
		116.5	28.04	412	27.05	181	17.71	74
		119.5	16.67	245	16.43	110	9.73	40
		122.5	14.39	211	7.24	49	4.49	19
		125.5	6.82	100	1.93	13	2.99	12
		128.5	2.27	33	0	0	8.73	36
		131.5	2.27	33	1.45	10	**2.00**	8
		134.5	1.52	22	0	0	0.00	0
		137.5	0	0	0.97	7	0.00	0
		Total	100.00	1468	100	670	100.00	415

7.6.3.1.4 Trends in growth

No data available or analyses undertaken.

7.6.3.1.5 Trends in maturity

In Romanian waters the overall sex ratio of males was significantly positive with a rate of 84.29% compared to only 15.61 females. In Bulgarian waters, the majority of the piked dogfish were females.

7.6.4 Assessment of historic parameters

7.6.4.1 Justification

The EWG 11-16 did not perform any analytical assessment. Instead, further data quality and completeness checks will be performed as a preparation of next meeting of STECF Black Sea fisheries experts.

7.6.4.2 Input data available

Given the practice of previous studies, the picked dogfish can be assessed using age-structured methods (Prodanov et al. 1997, Shlyakhov, 1997, Daskalov 1998). Fisheries, biological (age and individual size and growth), trawl survey data and commercial CPUE from all countries need to be thoroughly compiled (Table 6.6.4.2.1).

At the first stage data must be carefully screened and organized into age structured matrices. Age structured assessment methods such as XSA can be applied similar to turbot.

Table 6.6.4.2.1. Data availability by country

Type of data	BG	RO	RF	TR	UKR
Official landings	1970-2009	1980-1995 2006-2009	1988-2009		1988-2009
Illegal, Unreported Catch		no	no		no
Fishing effort and CPUE		no			1989-2009
Number of fishing vessels		no	no		no
Research surveys		2003-2010			1989-1993, 1998
Length composition	2006-2010	2003-2010			1988-2009
Weight at length (survey, landings)	2006-2010	2003-2010			1988-2009
Age composition		no			1988-2009
Weight at age (survey, landings)		no			1988-2009
Maturity at age		no			1989-1993, 1998
Natural mortality		no			1989

Table 6.6.4.2.2 Ukrainian historical catch in number

Catch numbers at age				Numbers*10**-3						
YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	65	2	2	3	2	0	27	22	21	3
3	319	42	70	45	6	10	84	51	61	145
4	155	384	48	60	9	28	34	24	47	103
5	487	177	194	267	47	132	101	78	185	396
6	280	167	200	229	108	91	90	99	127	324
7	212	126	168	201	107	58	63	94	94	246
8	76	37	69	75	38	18	19	31	29	76
9	34	15	27	33	23	7	12	26	18	50
+gp	37	14	31	48	42	9	33	68	30	105
0 TOTALNUM	1665	964	808	961	382	353	463	493	612	1449
TONSLAND	5273	3052	3049	3705	1696	1273	1584	2012	2160	5447
SOPCOF %	100	100	100	100	100	100	100	100	100	100

Catch numbers at age				Numbers*10**-3						
YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
1	0	0	0	0	0	0	0	0	0	4
2	13	19	0	0	0	0	0	0	0	12
3	75	80	124	161	62	1	0	1	0	33
4	41	26	74	101	57	3	0	10	0	41
5	160	81	216	383	52	5	6	15	23	59
6	190	145	184	217	86	10	7	55	35	68
7	145	178	185	196	92	19	15	16	29	35
8	48	97	82	79	76	9	0	16	45	17
9	25	54	76	72	52	15	3	10	10	16
+gp	51	89	169	153	138	33	39	49	66	52
0 TOTALNUM	747	770	1110	1363	615	95	72	171	209	335
TONSLAND	2843	3276	4662	5307	2852	527	428	849	1116	1452
SOPCOF %	100	100	100	100	100	100	100	100	100	100

Catch numbers at age				Numbers*10**-3						
YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
1	20	55	18	201	1	19	76	0	0	0
2	56	71	43	436	123	67	38	0	0	0
3	69	121	29	366	283	47	40	62	9	69
4	106	88	30	151	224	309	129	48	26	113
5	96	60	17	63	204	483	167	43	73	75
6	37	47	13	26	63	245	208	50	175	182
7	30	36	15	15	45	86	96	68	96	145
8	21	8	10	15	39	19	42	32	54	25
9	13	6	2	11	34	2	10	13	11	13
+gp	36	6	2	3	10	2	0	3	0	6
0 TOTALNUM	484	498	180	1287	1026	1280	808	319	444	628
TONSLAND	1392	935	438	1601	2139	2924	2031	1014	1574	1933

SOPCOF %	99	98	100	100	100	100	101	100	100	100

Catch numbers at age		Numbers*10**-3								
YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
1	4	0	0	1	1	2	11	14	4	0
2	110	28	32	9	7	27	51	56	51	29
3	98	42	62	15	18	80	69	104	55	76
4	132	131	47	14	23	82	93	198	124	85
5	107	244	55	24	28	57	69	95	79	55
6	78	319	38	34	31	27	42	49	53	32
7	197	102	27	37	21	23	36	18	28	40
8	110	22	2	6	11	15	7	2	10	7
9	57	3	0	0	1	1	9	2	2	1
+gp	17	8	1	0	0	0	0	0	1	0
0 TOTALNUM	910	898	264	142	143	314	387	539	406	325
TONSLAND	2776	2522	592	408	425	726	959	1030	811	706
SOPCOF %	103	100	100	100	103	100	100	96	96	100

6.6.4.2.3 Ukrainian historical catch weights (Kg)

Catch weights at age (kg)										
YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
1	.6140	.6140	.6140	.6140	.6140	.6140	.6140	.6140	.6140	.6140
2	1.0830	1.0830	1.0830	1.0830	1.0830	1.0830	1.0830	1.0830	1.0830	1.0830
3	1.6460	1.6460	1.6460	1.6460	1.6460	1.6460	1.6460	1.6460	1.6460	1.6460
4	2.2920	2.2920	2.2920	2.2920	2.2920	2.2920	2.2920	2.2920	2.2920	2.2920
5	3.0040	3.0040	3.0040	3.0040	3.0040	3.0040	3.0040	3.0040	3.0040	3.0040
6	3.7310	3.7310	3.7310	3.7310	3.7310	3.7310	3.7310	3.7310	3.7310	3.7310
7	4.4560	4.4560	4.4560	4.4560	4.4560	4.4560	4.4560	4.4560	4.4560	4.4560
8	5.1700	5.1700	5.1700	5.1700	5.1700	5.1700	5.1700	5.1700	5.1700	5.1700
9	5.8760	5.8760	5.8760	5.8760	5.8760	5.8760	5.8760	5.8760	5.8760	5.8760
+gp	7.4580	7.4580	7.4580	7.4580	7.4580	7.4580	7.4580	7.4580	7.4580	7.4580
0 SOPCOFAC	.9999	1.0001	.9999	1.0001	.9998	1.0001	1.0003	1.0002	1.0001	1.0000

Catch weights at age (kg)										
YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989

AGE										
1	.6140	.6140	.6140	.6140	.6140	.6140	.6140	.6140	.6140	.5000
2	1.0830	1.0830	1.0830	1.0830	1.0830	1.0830	1.0830	1.0830	1.0830	1.0000
3	1.6460	1.6460	1.6460	1.6460	1.6460	1.6460	1.6460	1.6460	1.6460	1.4000
4	2.2920	2.2920	2.2920	2.2920	2.2920	2.2920	2.2920	2.2920	2.2920	1.8000
5	3.0040	3.0040	3.0040	3.0040	3.0040	3.0040	3.0040	3.0040	3.0040	2.2000
6	3.7310	3.7310	3.7310	3.7310	3.7310	3.7310	3.7310	3.7310	3.7310	3.3000
7	4.4560	4.4560	4.4560	4.4560	4.4560	4.4560	4.4560	4.4560	4.4560	4.0000
8	5.1700	5.1700	5.1700	5.1700	5.1700	5.1700	5.1700	5.1700	5.1700	5.3000
9	5.8760	5.8760	5.8760	5.8760	5.8760	5.8760	5.8760	5.8760	5.8760	6.6000
+gp	7.4580	7.4580	7.4580	7.4580	7.4580	7.4580	7.4580	7.4580	7.4580	12.1170
0 SOPCOFAC	1.0001	1.0002	.9999	1.0001	1.0001	1.0002	.9991	.9995	1.0004	1.0001

Catch weights at age (kg)										
YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
1	.4570	.3830	.7270	.4530	.6000	.0900	.4170	.4170	.4170	.4170
2	.7300	.7770	.9470	.8930	.7600	.7200	.8220	.8220	.8220	.8220
3	1.2470	1.1530	1.4270	1.1000	1.0700	.9530	1.0000	1.0000	1.3000	1.3000
4	1.7770	1.7100	1.9970	1.5430	1.5930	1.5700	1.6000	1.6000	1.7000	1.7000
5	2.1600	2.1200	2.6470	2.0870	2.0830	2.2200	2.1000	2.1000	2.2000	2.2000
6	3.2430	3.0300	3.9070	2.9630	2.5970	2.9930	2.8000	2.8000	3.1000	3.1000
7	3.9000	4.2570	5.2830	4.4430	4.2000	4.4230	4.3000	4.3000	4.3000	4.3000
8	5.4470	5.4670	6.3000	5.8200	5.9000	6.0000	6.0000	6.0000	6.0000	6.0000
9	6.5000	6.6000	8.8000	8.3400	8.3000	8.5000	9.5000	9.5000	7.0000	7.0000
+gp	12.2780	12.3520	9.5370	9.3690	9.4730	9.5000	10.3140	10.5000	10.3140	9.5000
0 SOPCOFAC	.9875	.9820	.9999	1.0002	1.0001	1.0000	1.0124	1.0000	.9999	1.0000

Catch weights at age (kg)										
YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										

1	.1800	.4170	.4170	.4770	.4860	.1600	.6210	.2910	.2130	.0100
2	.4300	.8220	.8520	.7930	.9730	.8430	.9990	.7940	.5710	.6600
3	1.2270	1.3000	1.2830	1.2920	1.4290	1.3210	1.5070	1.4000	1.3560	1.1550
4	1.5670	1.7000	1.9380	1.9750	1.9530	1.9380	2.1140	1.8910	1.7910	1.7490
5	2.2230	2.3000	2.5320	2.4000	2.5170	2.5450	2.6800	2.4410	2.4200	2.4230
6	2.8700	3.1000	3.1970	3.1160	3.1830	3.4360	3.5010	3.1190	3.0010	3.4150
7	3.9130	4.1000	4.1170	4.0780	4.2380	4.3880	4.4670	4.7060	4.0150	4.1970
8	5.2330	5.7000	5.4000	5.4000	5.7960	5.7800	5.8280	6.0600	4.6940	5.1920
9	6.6200	9.5000	6.6000	6.6000	6.8000	7.5000	7.4000	7.5000	5.6970	6.3230
+gp	8.3210	12.6670	10.2500	10.0000	10.3140	9.8420	10.3140	9.0000	6.6430	.0100
0 SOPCOFAC	1.0268	1.0031	.9997	1.0015	1.0310	.9987	1.0021	.9631	.9595	.9996

6.6.4.2.4 Ukrainian historical stock weights at age (Kg)

Stock weights at age (kg)										
YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
1	.6140	.6140	.6140	.6140	.6140	.6140	.6140	.6140	.6140	.6140
2	1.0830	1.0830	1.0830	1.0830	1.0830	1.0830	1.0830	1.0830	1.0830	1.0830
3	1.6460	1.6460	1.6460	1.6460	1.6460	1.6460	1.6460	1.6460	1.6460	1.6460
4	2.2920	2.2920	2.2920	2.2920	2.2920	2.2920	2.2920	2.2920	2.2920	2.2920
5	3.0040	3.0040	3.0040	3.0040	3.0040	3.0040	3.0040	3.0040	3.0040	3.0040
6	3.7310	3.7310	3.7310	3.7310	3.7310	3.7310	3.7310	3.7310	3.7310	3.7310
7	4.4560	4.4560	4.4560	4.4560	4.4560	4.4560	4.4560	4.4560	4.4560	4.4560
8	5.1700	5.1700	5.1700	5.1700	5.1700	5.1700	5.1700	5.1700	5.1700	5.1700
9	5.8760	5.8760	5.8760	5.8760	5.8760	5.8760	5.8760	5.8760	5.8760	5.8760
+gp	7.4580	7.4580	7.4580	7.4580	7.4580	7.4580	7.4580	7.4580	7.4580	7.4580

Stock weights at age (kg)										
YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
1	.6140	.6140	.6140	.6140	.6140	.6140	.6140	.6140	.6140	.5000

2	1.0830	1.0830	1.0830	1.0830	1.0830	1.0830	1.0830	1.0830	1.0830	1.0000
3	1.6460	1.6460	1.6460	1.6460	1.6460	1.6460	1.6460	1.6460	1.6460	1.4000
4	2.2920	2.2920	2.2920	2.2920	2.2920	2.2920	2.2920	2.2920	2.2920	1.8000
5	3.0040	3.0040	3.0040	3.0040	3.0040	3.0040	3.0040	3.0040	3.0040	2.2000
6	3.7310	3.7310	3.7310	3.7310	3.7310	3.7310	3.7310	3.7310	3.7310	3.3000
7	4.4560	4.4560	4.4560	4.4560	4.4560	4.4560	4.4560	4.4560	4.4560	4.0000
8	5.1700	5.1700	5.1700	5.1700	5.1700	5.1700	5.1700	5.1700	5.1700	5.3000
9	5.8760	5.8760	5.8760	5.8760	5.8760	5.8760	5.8760	5.8760	5.8760	6.6000
+gp	7.4580	7.4580	7.4580	7.4580	7.4580	7.4580	7.4580	7.4580	7.4580	12.1170

Stock weights at age (kg)										
YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
1	.4570	.3830	.7270	.4530	.6000	.0900	.6140	.6140	.6140	.6140
2	.7300	.7770	.9470	.8930	.7600	.7200	1.0830	1.0830	1.0830	1.0830
3	1.2470	1.1530	1.4270	1.1000	1.0700	.9530	1.0000	1.0000	1.3000	1.3000
4	1.7770	1.7100	1.9970	1.5430	1.5930	1.5700	1.6000	1.6000	1.7000	1.7000
5	2.1600	2.1200	2.6470	2.0870	2.0830	2.2200	2.1000	2.1000	2.2000	2.2000
6	3.2430	3.0300	3.9070	2.9630	2.5970	2.9930	2.8000	2.8000	3.1000	3.1000
7	3.9000	4.2570	5.2830	4.4430	4.2000	4.4230	4.3000	4.3000	4.3000	4.3000
8	5.4470	5.4670	6.3000	5.8200	5.9000	6.0000	6.0000	6.0000	6.0000	6.0000
9	6.5000	6.6000	8.8000	8.3400	8.3000	8.5000	9.5000	9.5000	7.0000	7.0000
+gp	12.2780	12.3520	9.5370	9.3690	9.4730	9.5000	7.4580	10.5000	10.3140	9.5000

Stock weights at age (kg)										
YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
1	.1800	.6140	.6140	.6140	.4860	.1600	.6210	.2910	.2130	.0100
2	1.0830	1.0830	.8520	.7930	.9730	.8430	.9990	.7940	.5710	.6600
3	1.2270	1.3000	1.2830	1.2920	1.4290	1.3210	1.5070	1.4000	1.3560	1.1550
4	1.5670	1.7000	1.9380	1.9750	1.9530	1.9380	2.1140	1.8910	1.7910	1.7490

5	2.2230	2.3000	2.5320	2.4000	2.5170	2.5450	2.6800	2.4410	2.4200	2.4230
6	2.8700	3.1000	3.1970	3.1160	3.1830	3.4360	3.5010	3.1190	3.0010	3.4150
7	3.9130	4.1000	4.1170	4.0780	4.2380	4.3880	4.4670	4.7060	4.0150	4.1970
8	5.2330	5.7000	5.4000	5.4000	5.7960	5.7800	5.8280	6.0600	4.6940	5.1920
9	6.6200	9.5000	6.6000	6.6000	6.8000	7.5000	7.4000	7.5000	5.6970	6.3230
+gp	8.3210	12.6670	10.2500	10.0000	7.4580	9.8420	7.4580	9.0000	6.6430	.0100

6.6.4.2.5 Ukrainian data on maturity ogive

Table 5 Proportion mature at age										
YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
1	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
2	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
3	.4500	.4500	.4500	.4500	.4500	.4500	.4500	.4500	.4500	.4500
4	.7000	.7000	.7000	.7000	.7000	.7000	.7000	.7000	.7000	.7000
5	.9500	.9500	.9500	.9500	.9500	.9500	.9500	.9500	.9500	.9500
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
+gp	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Proportion mature at age										
YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
1	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
2	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
3	.4500	.4500	.4500	.4500	.4500	.4500	.4500	.4500	.4500	.4500
4	.7000	.7000	.7000	.7000	.7000	.7000	.7000	.7000	.7000	.7000

5	.9500	.9500	.9500	.9500	.9500	.9500	.9500	.9500	.9500	.9500
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
+gp	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Proportion mature at age										
YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
1	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
2	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
3	.4500	.4500	.4500	.4500	.4500	.4500	.4500	.4500	.4500	.4500
4	.7000	.7000	.7000	.7000	.7000	.7000	.7000	.7000	.7000	.7000
5	.9500	.9500	.9500	.9500	.9500	.9500	.9500	.9500	.9500	.9500
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
+gp	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Proportion mature at age										
YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
1	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
2	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
3	.4500	.4500	.4500	.4500	.4500	.4500	.4500	.4500	.4500	.4500
4	.7000	.7000	.7000	.7000	.7000	.7000	.7000	.7000	.7000	.7000
5	.9500	.9500	.9500	.9500	.9500	.9500	.9500	.9500	.9500	.9500
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
+gp	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

6.6.4.2.6 Ukrainian dogfish age/length key (1996-1997)

1996				A/SL key								
	81-85	86-90	91-95	96-100	101-105	106-110	111-115	116-120	121-125	126-130	131-135	136-140
6	0.036	0.01	0.009										
7	0.131	0.07	0.044										
8	0.298	0.18	0.132	0.0402	0.034	0.01							
9	0.274	0.26	0.228	0.1609	0.092	0.043		0.011					
10	0.143	0.33	0.237	0.2414	0.169	0.086	0.053	0.033					
11	0.119	0.09	0.184	0.2586	0.179	0.187	0.152	0.065	0.013	0.03704			
12		0.02	0.123	0.1897	0.217	0.211	0.181	0.054	0.038	0.04938			
13		0.01	0.044	0.0977	0.217	0.201	0.158	0.087	0.114	0.07407			
14		0.01		0.0115	0.092	0.177	0.24	0.185	0.228	0.08642			
15						0.072	0.181	0.413	0.165	0.23457			
16						0.014	0.035	0.109	0.278	0.22222	0.1111	0.25	
17								0.043	0.139	0.20988	0.2778	0.375	
18									0.025	0.08642	0.3889	0.125	0.25
19											0.1667	0.125	0.375
20											0.0556	0.125	0.125
21												0.166667	0.125
22												0.055556	0.125

1997				A/SL key								
	81-85	86-90	91-95	96-100	101-105	106-110	111-115	116-120	121-125	126-130	131-135	136-140
6	0.0357	0.0115	0.0088										

7	0.131	0.069	0.0439										
8	0.2976	0.1839	0.1316	0.0402	0.0338	0.0096							
9	0.2738	0.2644	0.2281	0.1609	0.0918	0.0431		0.011					
10	0.1429	0.3333	0.2368	0.2414	0.1691	0.0861	0.0526	0.033					
11	0.119	0.092	0.1842	0.2586	0.1787	0.1866	0.152	0.065	0.013	0.037			
12		0.023	0.1228	0.1897	0.2174	0.2105	0.1813	0.054	0.038	0.0494			
13		0.0115	0.0439	0.0977	0.2174	0.201	0.1579	0.087	0.114	0.0741			
14		0.0115		0.0115	0.0918	0.177	0.2398	0.185	0.228	0.0864			
15						0.0718	0.1813	0.413	0.165	0.2346			
16						0.0144	0.0351	0.109	0.278	0.2222	0.1111	0.25	
17								0.043	0.139	0.2099	0.2778	0.375	
18									0.025	0.0864	0.3889	0.125	0.25
19											0.1667	0.125	0.375
20											0.0556	0.125	0.125
21												0.1667	0.125
22												0.0556	0.125

7.6.5 Scientific advice

7.6.5.1 Short term considerations

State of the spawning stock size:
Given the status of the data provided the EWG 11-16 did not undertake any analytical assessment and is not in a position to provide advice.

State of recruitment:
Given the status of the data provided the EWG 11-16 did not undertake any analytical assessment. and is not in a position to provide advice.

State of exploitation:
Given the status of the data provided the EWG 11-16 did not undertake any analytical assessment. and is not in a position to provide advice.

7.6.5.2 Medium term considerations

Given the status of the data provided the EWG 11-16 did not undertake any analytical assessment.

7.7 Rapa whelk in the Black Sea

7.7.1 Biological features

7.7.1.1 Stock Identification

The Rapa whelk (*Rapana venosa*) was introduced into the Black Sea in the 1940s and within a decade spread along the Caucasian and Crimean coasts and to the Sea of Azov. Its range extended into the northwest Black Sea to the coastlines of Romania, Bulgaria and Turkey from 1959 to 1972 (Global Invasive Species Database (http://www.issg.org/database). *R. venosa* is well established in the benthic ecosystem of all Black Sea coastal states and has exerted significant predatory pressure on the indigenous malacofauna (Black Sea TDA, 2008).

The impact on bivalve populations is variable and ranges from rather mild along the Romanian coast possibly due to suboptimal environmental condition,moderate in Bulgarian and Turkish Black Sea, and severe along Russian and Ukrainian coasts, where the whelk has been blamed for local exterminations or major declines in the numbers of other bivalves (Black Sea TDA, 2008).

In the Black Sea, *Rapana venosa* occurs on sandy and hard-bottom substrates to 45 m depth. The highest abundance occurs in the Kerch Strait at the entrance to the Sea of Azov, near Sevastopol and Yalta (Ukraine), and along the Bulgarian coast (ICES, 2004).

After the adaptation in the Black Sea ecosystem, it has being a dynamics stocks along whole Black Sea Coasts since 1969 (Bilecik, 1974). The whelk population has spread gradually onward to 1970s and also its stock has started increasing in coastal benthic extremely in 1980s. Rapa whelk has established and pressured on the bivalve communities for predation in the shallow waters in the Black Sea coast of Turkey (Bilecik, 1990).

R. venosa is a prolific, extremely versatile species tolerating low salinities, water pollution and oxygen deficient waters.Veined Rapa whelk becomes mature at the age of 2-3 old and has 8-9 years life span. Preferred habitats are shell substrates and shell bottoms with varying degrees of silting, but on the silt beds the Rapa whelk occurrence is not high. The species demands to salinity with the lower limit of its development about 12 ‰ and also to the temperature-at low temperatures the activity of Rapa whelk falls and if the temperature falls to 10° C, the species stop to feed. Local migrations of Rapa whelk have been associated with seasonal changes of water temperature and have been oriented toward the shore in the period of water heating during spring-summer season, and towards to depths in the autumn-winter cooling. Ciuhcin (1984) describes the reproductive period of *R. venosa* in the Black Sea as July to September, corresponding to a temperature window of $19^{o}C$ to $25^{o}C$. Sahin (1997) reports a spawning period of May to November in the eastern Black Sea. Females lay eggs in cocoons attached to the substrate. Each egg capsule contains 200-500 eggs. Pelagic larvae of sea snail feed on nanoplankton algae and their adults feed mainly on bivalves of families Cardiidae, Mytilidae, Veneridae, Archidae (GFCM:SAC12/2010). Looking for prey Rapa whelk is able to move on rather large distances. The speed of movement makes up from 5 till 20 cm/min. In some periods of a year it buries itself into the ground.

Introduction of this predatory mollusk into the ecosystem of the Black Sea turned out to be a catastrophe for oyster biocenoses. Distribution of Rapa whelk is associated with reduction in area and density of mussel settlements, in particular near the coasts of Anatolia and Caucasus. In the Ukrainian waters Rapa Whelk destroyed the oyster banks in the area of the Kerch Strait and in Karkinitsky Bay, biocenoses of other mollusks associated with depth down to 30 m suffered as well.

The Turkish investigations concerning biomass distribution of Rapa whelk by depth and season indicates that 76.5% of the population inhabits the depths of 0-15 m from the shore, 22.5 % in 15-35 m and the last 1.0% is in depths over 35m. The major factor for seasonal distribution is the sea water temperature. In summer, 62.5% of the population distributes in near shore of 0-15 m depths when the temperature reaches its maximum (Zengin, 2006). By the end of the reproduction activity and the decrease in sea water temperature, generally September, Rapa whelk moves to deeper waters and buried in substratum.

The Rapa whelk has no effective natural predator in Black Sea and this may also play an important role in population increase. Its feeding strategy depending dominantly on mussels (Cesari and Mizzan, 1993) and its high rate of predation depleted nearly all mussel stocks (*M. galloprovincialis, C. gallina, A. cornea*) distributed along the coasts from Georgia border to Ünye/Terme. It is recorded that 99% of *C.gallina* population is composed of empty shells in the period of 2002/2003 (Dalgıç and Karayücel, 2006). Actually this destructive effect started by the mid of 1990s because the observations verified that *C. gallina* population was still dynamic until 1995 in the South eastern Black Sea (Zengin, 2003). In surveys planned to estimate the amount of bycatch in the Rapa whelk commercial catches, the percent of empty shells was recorded as 73% and 85% for *Anadara cornea* and *Chamelea gallina,* respectively (Knudsen and Zengin, 2006). Recently, the rapa whelk starts to threaten some other mollusca and crustacean communities *(L. depurator,* Donax sp., Isopods, Amphipods and Decapods). It also threatens another egzotic Pacific originated species; Anadara cornea that invades Black Sea ecosystem in 1982.

7.7.1.2 Growth and natural mortality

According to the investigations conducted in the Black Sea shelf area and Kerch Strait found that the picked Rapa whelk was the age limit of 9 years and was characterized by such parameters of the equation Bertalanffy and natural mortality:

$K=0.687$ $t_0=-0.014$; $L_\infty= 9.55$ cm; M_t: $M_2= 0.12$, $M_3= 0.54$; $M_4= 1.28$, $M_5= 1.40$

Growth rate of *R. venosa* along Bulgarian Black Sea coast was investigated and population parameters and natural mortality coefficient were estimated (Prodanov et.al, 1995). The following values of von Bertalanffy parameters were established (Prodanov et.al, 1995):

$L_\infty= 123.98$ mm	$W_\infty = 423.75$ g
$k = 0.214$	$k = 0.1989$
$t_0 = -0.0822$	$t_0 = -0.2203$

The mean value of natural mortality coefficient was estimated at 0.5 (Prodanov et.al, 1995).

The length-weight relationship is determined as $W=0.9\times10^{-3}L^{3.1459.}$ According to Bhattacharya method, age classes ranged between 0 and 5 years, while growth parameters were estimated as $L_\infty = 103.97$ mm, $k = 0.345$, $t_0 = -0.310$ and $W_\infty = 213.52$ g.

7.7.1.3 Maturity

The sex ratio is 1:1.6 (female: male). The first maturity length is 4.0 cm. Spawning occurs between June and August (Düzgüneş et. al., 1997; Figure 6.7.1.3.1).

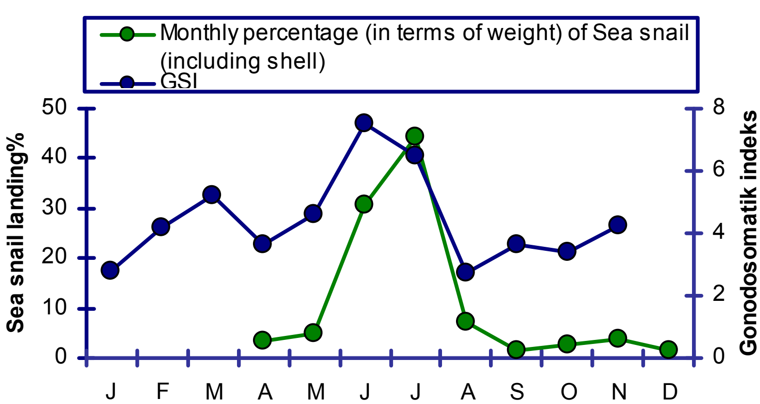


Figure 6.7.1.3.1. The relationship between the monthly landings and the reproduction period GSI of Rapa whelk.

7.7.2 Fisheries

7.7.2.1 General description

Rapa whelk has become a commercially valuable resource with high demand on the international market. The commercial value of this resource increased initially in Turkey during 1980s and then in Bulgaria (1990s). In Romania, mediumlarge scale 'subsistence' harvesting is likely to develop into an export-oriented industrial-scale enterprise in future years. In Ukraine *R. venosa* uses are limited to local subsistence fishery and souvenir manufacture/trade (Black Sea TDA, 2008, BSC SOE, 2008).

Positive economic effects from *R. venosa* fishery are counteracted by negative ecological side-effects of destructive fishing practices used in Turkey and Bulgaria where *R. venosa* is fished with dredges and beam trawls, in the latter country illegaly (Black Sea TDA, 2008). In contrast, in Romania *R. venosa* is selectively fished by SCUBA divers, a sustainable method which does not disturb the habitat or involve by-catches of other animals. However, signs of over-harvesting are already evident in some areas (Black Sea TDA, 2008).

In Bulgaria, Rapana fisheries started in 1994 by method of scuba diving, but later illegal use of beam trawls have been also observed. For that reason, the official landings are misreported to some extent. Due to fact, that the Rapa whelk products are export orientated, the real value of catches could be estimated by official export data.

CFRI was participated in a study (Knudsen et al., 2010) evaluating the rapa whelk fishery by its socio-economic and administrative structure and also its population structure and predation on benthic habitats and bivalves communities. Following the years of 2006-2008 a study was carried out to develop new technologies to mitigate the effects of traditional dredges and beam trawls on benthic ecosystem. In this study, the efficiency of new trap models was tested and it is tried to determine whether they can be an alternative to traditional fishing methods (Sağlam et al., 2008). But the different trap models were found insufficient by the fishermen. These trap models were unfortunately not used in practice, even though they were supported financially by Fishery Cooperatives and the rapa whelk processors in Samsun (Yesilirmak-Kizilırmak) where the rapa whelk intensely exploited along Turkish coasts. The fishermen did not use these new catch device and they continue with their traditional methods.

Besides, the technical report (Iotov, 2011) prepared by European Union Commission, regarding the status of Black Sea Fishery for the date and the future management that was presented to European Parliament revised the case of rapa whelk in Black Sea as other species. "The report focuses on the importance of research to define the safest fishing techniques for demersal stocks, particularly the veined rapa whelk (*Rapana venosa*). This is of particular importance for the ecosystem of the Black Sea, as it has been revealed that rapa whelk is in the position of 'a predator without enemy thus exercising great pressure on natural filters of sea waters like blue mussel (*Mytilus galloprovincialis*) and striped venus clam (*Chamelea gallina*), and seriously endangering the ecological balance of the Black Sea.

Regarding this importance, though several research from different localities are working on several aspects such as biology, population and ecology of rapa, still little is known and the present data is lack of standard. We have no retrospective data including time-series and the data provided already is not sufficient in quantity and quality for a stock assessment model. Furthermore, there is no current study on rapa considering the parameters required for stock assessment in all Black Sea countries. If a stock assessment program is planned to be run, the first attempt have to be the development of a standardized method for data collection and storing.

The future work flow for rapa whelk was discussed by Black Sea WG and it was concluded to monitor rapa with case studies at least for now and to encourage countries to plan surveys in order to collect new data with a standard methodology required in stock assessment procedure.

7.7.2.2 Management regulations applicable in 2010 and 2011

In Bulgaria, fisheries on *Rapana* are permitted only by scuba diving method and license system in also in force. In Ukraine, annual limit for sea snail harvesting up to 400 t has been introduced since 2002.

In Turkey, MARA implemented some limitations to the fishery of Rapa whelk by yearly circulars those can be mentioned in three items. The first was the fishing method that permits scuba diving in western part while dredges (mesh size as minimum 40 mm) are allowed in eastern part. The second was about fishing period. Scuba diving was allowed throughout all year but dredges are banned between 1 May and 30 August. In addition, fishing at nights was also banned. The third one is about the area limitations such as closure of 500 m far from the coast. Actually, these limitations never came into use and illegal fisheries increased in following years. The possible reasons for illegal fisheries may be considered as:

1. The Rapa whelk migrates to the coastal zone to reproduce in summer months (5-15 m depths) and the illegal fishery increases especially in this period due to abundance and the gear efficiency resulted in higher catches. The Rapa whelk population moves to deep water in autumn when the temperature lows and so the decrease of the catch in this legal period compels the fisherman to illegal activities (Figure 6.7.2.2.1).

2. The meat yield reaches its highest percent in summer and landing costs higher. In the legal period (autumn) the condition of Rapa whelk declines, so the meat yields and the fabrics involuntary to pay well prices (Figure 9).

3. In this legal period the artisanal fisherman who catch Rapa whelk leaves the dredges and directs to bonito fishing which is more profitable.

4. Except the banned period some of small scaled fisherman works as a crew in large vessels (trawls and purse seines) and already have a job. By the closure of the fishing season for the large vessels, they want to drive profit from Rapa whelk and fish in the illegal season.

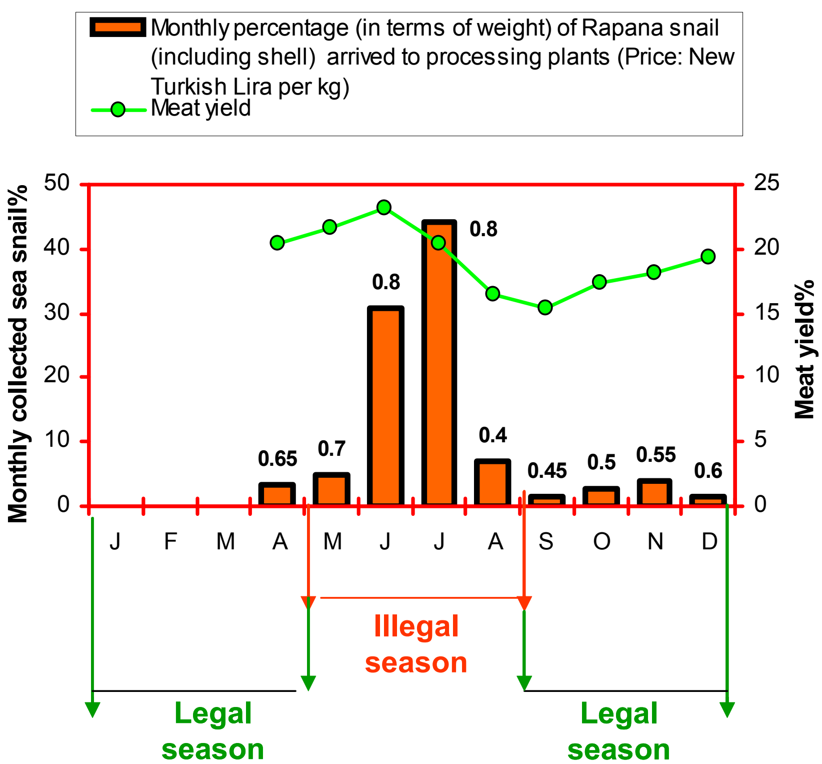


Figure 6.7.2.2.1. The diagram of the relations between fishing season, landing, meat yield and price for Turkey (Zengin, 2005).

7.7.2.3 Catches

7.7.2.3.1 Landings

Turkey has been conducting large-scale harvesting of sea snail since the mid -1980s. The Turkish catch remained, however, much higher than other countries, followed by Bulgaria (*BSC SOE, 2008, GFCM Capture Production 1970-2006, National Fisheries Statistics 2007-2009*). Table 6.7.2.3.1.1 list the national landings.

In Turkey, harvesting of sea snail has been firstly permitted by MARA in 1983. The fishery sector expanded including fishermen, commission agents, industrial foundations such as fabrics etc., especially in Eastern Black Sea. In the beginning, 225 artisanal fishermen were operating with dredges (algarna) along eastern Black Sea, but the number of fishermen reached 421 by an increase of 87% in the next ten years (Zengin and Knudsen, 2006). Analysis of fisheries along the eastern coast of Turkey (Samsun Province) showed that number of vessels using dredges for sea snail harvesting in 2000 - 2005 increased by large rates, especially in the vessel group 33-149 HP. These are typical boats that combine sea snail dredging, bottom trawling and net fishing (Zengin, 2006). Although the resource of this mollusk is still withstanding such high intensity of fisheries, a large-scale implementation of dredges has a destructive effect on the bottom biocenoses and the ecosystems as a whole.

The Turkish fishermen, working on *Rapana venosa* mostly have vessels with 6-17 m in length. A single dredge is used in vessels smaller than 8 m and the larger ones generally used a pair of dredges. Actually, the use of double dredges is prohibited by government regulations. But fisherman generally uses them to obtain more product and they continue fishing also at night illegally. The number of vessels in Samsun district was 421 by 2005 and nearly half of them (232) had no licences for rapa whelk fishing. These vessels intensely operates in inshore benthic between depths of 5 and 33 m but mostly around 13 m.

The landings of rapa whelk in Eastern Black Sea was 10 000 t in 1989, averagely changed around 3 000 tons (1 - 6 tonnes) between 1990 and 2000 according to TUIK official data. In the following decade landing of rapa whelk increased and reached its maximum as 14 000 t in 2004. This trend continued more or less stable (11 000-14 000 tons) until 2009. A sudden decrease was recorded in landing as 6 000 tons in 2009. The increase in 2000 - 2010 may be explained by the depletion of major demersal stocks in the area and work of fisherman on rapa whelk fishery for economical advantages. In 2010, there is a slight increase in Turkey's rapa catch. A similar trend can be observed also in Bulgaria and Ukranian production (Fig. 6.7.2.3.1.1).

Until the early1990s, along the Ukrainian coast, the sea snail was harvested in an amateurish way for fine shells used as souvenirs (BSC SOE, 2008). At the same time the meat of harvested mollusks was thrown away, and rarely it was used as feed for animals and more rarely as an exotic food for humans. Along the coasts of Ukraine the densest concentrations of Rapa whelk are found in depth 3-15 meters along the coast of the Crimea from Mezhvodnoye (the Karkinitsky Bay) to the Cape Takil and in the Kerch Strait. It is in this area of the Black Sea where a specialized harvesting (by Khizhyak's drags and hand harvesting of divers) for Rapa Whelk has been conducted since 1995. In the Black Sea the maximum harvesting of Rapa Whelk was observed in 2000 at the level of 913 tons, among which 325 tons were harvested on the ground Cape Takil – Feodosia by 19 gangs of harvesters, equipped with aqualungs and using 7 drags. In the Kerch Strait the maximum harvest of Rapa Whelk made up 49 tons in 2007.

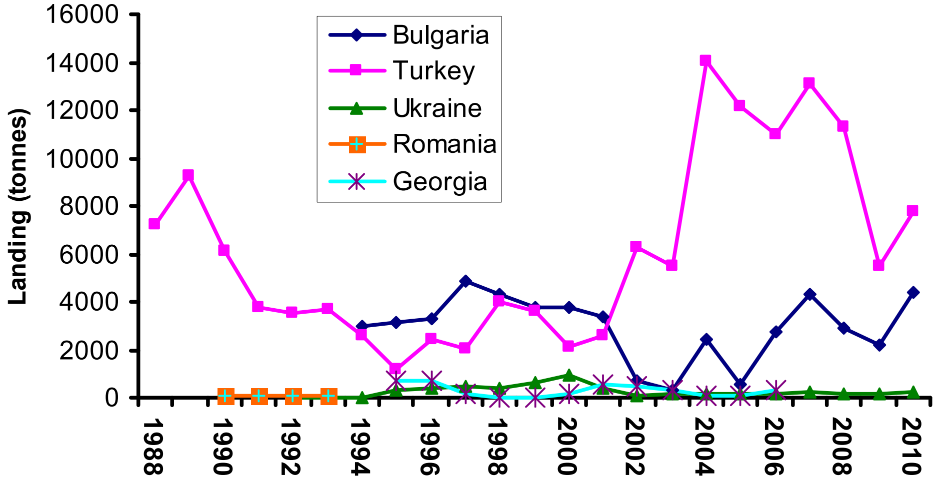


Fig. 6.7.2.3.1.1 The official landings of rapa whelk in Black Sea by countries between 1988 and 2010.

Table 6.7.2.3.1.1 Rapa whelk landings (t) by countries (FAO Fisheries Statistics, GFCM Capture Production 1970 – 2006 and National Fisheries Statistics 2007 - 2009).

Year	Bulgaria	Romania	Turkey	Georgia	Ukraine
1970	.	-	-	.	.
1971	.	-	-	.	.
1972	.	-	-	.	.
1973	.	-	-	.	.
1974	.	-	-	.	.
1975	.	-	-	.	.
1976	.	-	-	.	.
1977	.	-	<0.5	.	.
1978	.	-	-	.	.
1979	.	-	65	.	.
1980	.	-	-	.	.
1981	.	-	-	.	.
1982	.	-	-	.	.
1983	.	-	235	.	.
1984	.	-	122	.	.
1985	.	-	78	.	.
1986	.	-	2030	.	.
1987	.	-	643	.	.
1988	.	-	7195	-	-
1989	.	-	9239	-	-
1990	.	75	6094	-	-
1991	.	70	3738	-	-
1992	.	110	3519	-	14
1993	.	45	3668	-	3
1994	3000	-	2607	-	5
1995	3120	-	1198	700	303
1996	3260	-	2447	711	376
1997	4900	-	2021	118	476
1998	4300	-	3998	.	369
1999	3800	-	3588	.	619
2000	3800	-	2145	184	913
2001	3353	-	2614	517	395
2002	698	-	6241	503	91
2003	325	-	5501	295	149
2004	2428	-	14035	65	159
2005	511	-	12156	70	161
2006	2773	-	10944	300	156
2007	4310		13106		201
2008	2872		11268		135
2009	2214		5460		190
2010	4381		7770		225

Prior to the beginning of Rapa whelk regular harvesting in Bulgaria, the biomass on the coastal grounds between Kaliakra and Pomorie was assessed at about 2 thousand tons (Prodanov and Konsulova, 1993). Taking into account all the area and the buried part of mollusks, its total biomass was assessed as 7.5 thousand tons. The average shell length of sea snail in 1984 was 71.1 mm (Prodanov and Konsulova, 1995). Bottom trawling and dredging were officially forbidden, although these fishing gears were used for the sea snail fishery. According to the assessments of the Private Bourgas Fishery Association, sea snail landings almost 7 times higher than the official report 8557 tons in 2005 (TDA Technical Task Team National Experts, Bulgaria report, Raykov, 2006).

Illegal bottom trawling for harvesting of *Rapana venosa* along the Bulgarian Black Sea shelf has raised ecological concerns with respect to the benthic communities and especially the mussel beds. The population decline of the habitat-structuring species *Mytilus galloprovincialis* in the impacted areas was accompanied by degradation of the associated benthic community from "mussel bed" type to "silt bottom" type dominated by opportunistic polychaetes and oligochaetes (Zenetos et al, 2007).

National Agency of Fisheries and Aquaculture start to collect data for export of Rapa whelk and CPUE data, which could be used for estimation of real value of landings – Table 7.7.2.3.1.2.

Table 6.7.2.3.1.2. Export data of Bulgaria for *R. venosa* in 2009.

Origin BULGARIA	Net weight (kg)
Frozen Rapa whelk	146164
frozen sweetbread from Rapa whelk	326178
frozen meat from Rapa whelk	572102
frozen meat from Rapa whelk with shells	59204
Total	**1103648**

In the Romanian Black Sea sector, *R. venosa* was first found in 1961, at the mouths of the Danube (Grossu, 1964), from where it rapidly spread towards the South, becoming a common species (Gomoiu, 1972). Today it is encountered on all types of substratum (rocky, sandy, muddy) at depths between 3 and 45 m, the maximum densities being registered on the natural and artificial substrata.

Investigations on R.venosa were conducted in the Romanian Black sea area during the period 2006-2008 and the following results were obtained:

1. The average length of the about 7,000 Rapana individuals selected ranged between 35 and 120 mm, the modal length being 90 mm, while the average one - 87.08 ± 0.36 mm. The average numeric density is 0,88 ± 0,02 ind/m-2, which corresponds to a total population of 100,16 ± 2.25 million Rapana individuals on the rocky substratum (113.53 km2) on the Romanian sector of the Black Sea littoral.

2. The total number of capsules laid by the female during one reproductive season (laboratory rearing) varied between 184 and 450, while the number of eggs in one capsule was 976. Thus, the fecundity was estimated between 179.000 and 400.000 eggs/ind-1/an-1.

3. The size of the eggs is 230-250 µm, while that of the newborn larva shell is 0.41 x 0.3 mm. The intercapsular development duration until hatching was of 14-17 days, at a 20°C temeparture. The veliger larvae are planktotrophes and can survive in the plankton for a long time (80 days), ensuring the long distance spreading, provided they find sufficient food in the plankton. If the plankton contains sufficient food, the larvae can metamorphose and start their benthic life in only 5-7 days.

4. The population diversity on the Romanian Black Sea Sector is higher than those of the populations in the Northern Adriatic Sea, despite the smaller distances between the collecting stations. This high diversity is probably due to the fact that pontic populations are 10-30 years older than those in the Mediterranean basin.

5. The R. venosa stocks in the Romanian Black Sea sector were estimated for the first time. The underwater transects method for stock evaluation was used as a premiere in the Black Sea basin. The commercial R. venosa stock was estimated around 13.19 ± 0.42 thousand tons, while the TAC level recommended for the fishery management is la 5.7 ± 0.2 thousand tons. We consider that, presently, the stock can sustain a much greater fishing effort, thus we recommend the temporary suspension of the prohibition period for this species.

6. The age of R. venosa was determined for the first time through sclerochronology.

7. The first microsatellite library for the R. venosa species was created and six microsatellite loci were characterized as a premiere for this species.

8.The age at the first breeding was determined, 2-4 years, corresponding to a shell length of 70-80 mm. In order to ensure at least one reproduction during the life span of an individual, in order to restore the stocks to exploitations conditions, we recommend the modification of the minimum size allowed by the catch from 50 mm, presently, to 80 mm.

9. The impose phenomenon (developing penis and different vessels) was presented for the first time in the Black Sea in R. venosa females, caused by TBT pollution and manifested through the presence of a penis and different unfunctional vessels in females.
The official catches reported at the Romanian littoral (кg) are: in 2008 - 85 кg and in 2009 – 1761 kg. The catches are obtained by hand of divers.

7.7.2.3.2 Discards

No information available to the EWG 11-16.

7.7.2.4 Fishing effort

No information available to the EWG 11-16 on specific rapa whelk fisheries.

7.7.2.5 Commercial CPUE

Table 6.7.2.5.1 . Catch per unit effort (kg/h) of Bulgaria on Rapa whelk fishery by fleet segments in 2008 and 2009.

leet Segment	LOA>0<6		LOA=>6<12		LOA=> 12<18		LOA=> 18<24		LOA=> 24<40	
Average CP	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Rapana RPN	305.69	238.38	461.88	529.95	722.83	611.99	744.84	768.24	no	no

The maximum catch is obtained in summer period in studies carried on with commercial dredges along Samsun in 2005 (Figure 6.7.2.5.1). The catch per unit of dredges in June and July is estimated as 70 and 100.9 kg/hour/vessel. The CPUE decreases in spring and autumn. It reaches to its minimum in spring; 5.7 and 26.3 kg/hour/vessel for April and May, respectively. It is considered to be related to temperature fall and the movement of *Rapana* to deeper waters. The CPUE increased slightly in autumn and estimated as 57.2 and 40.3 kg/hour/vessel for September and October.

The CPUE of beam trawls (algarnas) operating for rapa fishery from 2005 to 2010 were roughly estimated as 73.1 kg/h, 77.7 kg/h, 70.9 kg/h, 67.4 kg/h, 54.0 kg/h, 67.9 kg/h, respectively. The CPUE values seemed compatible with landings.

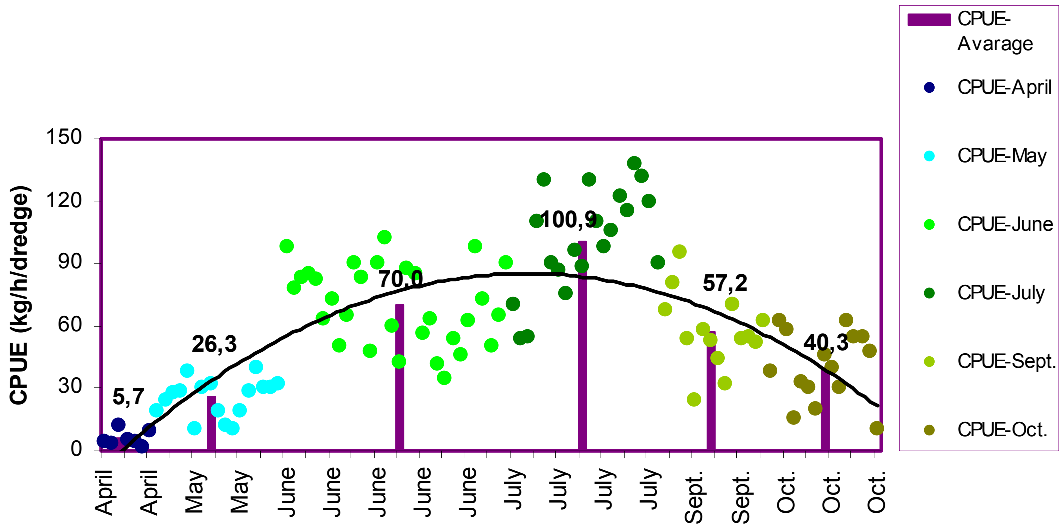


Figure 6.7.2.5.1. CPUE data obtained from rapa whelk commercial dredges in Samsun coasts for 2005.

The significant increase in Rapa whelk abundance has been observed since 1990, which leads to some ecological problems in near shore benthic communities. The feeding of Rapa whelk on bivalve species as a major source of food creates a high predation pressure that impacts both itself and other demersal species feeding on the same source. The scarcity of food lowers the growth rate of *Rapana* and prevents to reach harvestable length.

7.7.2.6 Historic information on stock status

7.7.2.6.1 Description

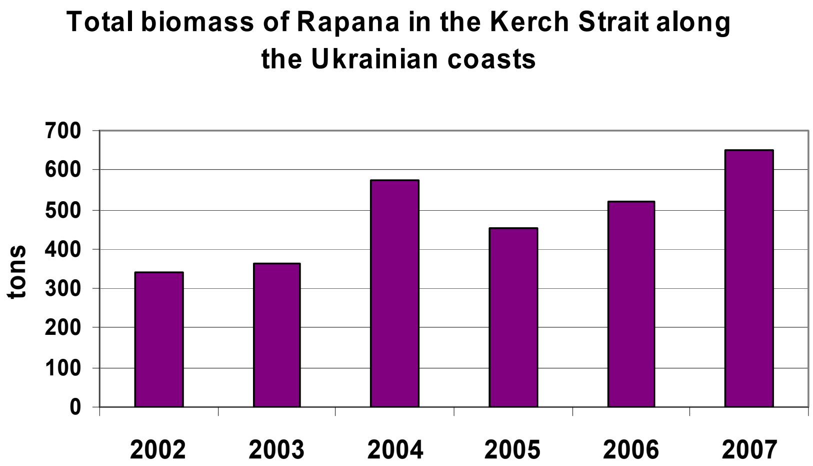
The earliest data about rapa whelk from Ukraine is length- frequency distributions for 1972 and 1973. These length compositions are up to 2008 with some intervals (Table 6.7.4.1.2.1). Research on biological parameters, distribution and stock assessment (by drags and visual divers' surveys) of Rapa Whelk in the Ukrainian territorial waters were undertaken in 1990, 1994 and 1998 in the area from Takil Cape to Chauda Cape. Stocks were respectively assessed as 2.8 thousand tons, 1.5 thousand tons and 1.3 thousand tons. The former two assessments belonged to the initial commercial exploitation of this ground, the latter – to the period of the intensive fisheries. Reduction in Rapa Whelk stocks from 1.5–2.8 thousand tons (virgin population in 1990-1994) down to 1.3 thousand tons (exploited population in 1998) is the evidence of drag fisheries impact. At the same time it is known that instead of the permitted by the Fisheries Regulations Khizhnyak's drag which is a sparing (protective) fishing gear of this class, knife-edge drags were widely used, affecting greatly the bottom biocenoses. In 1994 sea snail stocks were assessed along the southern and western coasts of the Crimea from Cape Ilya to the Cape Evpatoriisky. Sea snail stock was estimated in this area as 14 thousand tons, and the limit for its harvesting in the waters of Ukraine begin to be established as 3 thousand tons. After 2000 small-sized sea snail of 50-60 mm long was predominant in the catches from this ground. The causes of the observed rejuvenation of Rapa whelk population at present are difficult to establish without scientific research activities. The most probable cause is overfishing, accompanied by the intensive harvesting of individuals of older ages (more than 75 mm long) and great amount of the non-reported harvest. Therefore since 2002 annual limit for sea snail harvesting in the Ukrainian waters was reduced down to 400 tons. After limit reduction fisheries intensity and Rapa Whelk harvests reduced greatly and by mid 2000s there has been appeared information about increase in abundance and individual size of this mollusk near the coast of the Crimea. In Ukrainian waters of the Kerch Strait in recent years surveys of Rapa Whelk are made regularly. Their results are shown in Fig. 6.7.4.1.2.1.

7.7.2.6.2 Input parameters

The following table 6.7.4.1.2.1 lists historic size composition of Ukraine landings.

Table 6.7.4.1.2.1. Length composition of rapa whelk in Ukrainian waters of the Black Sea and Kerch Strait, %.

L, mm	Years																		
	1972	1973	87	89	90	92	94	97	98	99	2000	2001	2002	2003	2004	2005	2006	2007	2008
11-15																			
16-20																			
21-25																		1,0	
26-30		0,1																4,4	0,5
31-35			0,1															5,8	1,0
36-40			0,1						0,4						0,03			24,9	4,2
41-45	0,3	0,3	0,2						1,5	0,4	0,8	0,4		0,2	0,1			24,4	9,4
46-50	0,6	0,7	0,2						6,8	1,4	0,8	3,2		1,9	0,7		0,6	16,6	13,5
51-55	1,3	1,6	0,1					1,8	13,3	5,7	2,4	13,6	0,8	2,3	1,4		3,7	8,8	5,2
56-60	3,3	4,1	0,3	0,1				7,9	11,0	14,1	7,2	17,5	1,6	9,1	2,5	1,4	1,8	5,4	12,5
61-65	3,5	4,0	0,9	0,1		0,5	2,3	11,3	9,9	16,2	7,2	13,5	11,2	9,6	4,2	5,5	14,6	2,4	14,6
66-70	3,3	4,6	2,3	0,4	0,3	0,8	1,5	12,4	10,6	9,1	1,6	9,3	15,7	11,7	7,8	11,0	11,0	1,5	13,5
71-75	5,7	4,9	4,5	2,3	6,2	5,2	8,5	18,9	11,8	11,3	16,9	8,5	16,1	13,2	14,9	12,2	14,0	1,0	10,9
76-80	10,9	6,3	4,1	3,5	12,4	6,6	7,7	16,0	13,3	10,1	15,3	6,6	23,2	12,5	18,2	27,4	19,0	1,0	5,2
81-85	17,5	7,4	7,9	8,1	17,6	16,8	23,1	13,4	6,1	9,3	13,7	6,5	15,6	14,3	18,0	19,2	20,1	1,0	5,2
86-90	15,0	7,2	9,7	8,1	16,9	15,2	13,8	4,5	8,0	8,1	16,1	8,1	7,1	12,9	14,4	15,0	7,3	1,0	3,1
91-95	16,9	9,6	11,9	12,2	16,9	18,8	20,0	3,2	2,7	7,9	8,1	6,4	6,5	7,5	10,5	5,5	4,9	0,5	0,5
96-100	8,1	8,5	12,9	14,4	16,0	12,7	15,4	1,6	1,5	3,6	4,0	3,3	1	3,4	3,8	1,4	1,8	0,5	
101-105	4,4	10,9	12,6	15,7	4,9	12,1	6,1	3,7	1,1	1,0	3,2	1,9	0,4	1,1	1,8	1,4	1,2		
106-110	3,2	10,2	11,4	14,2	5,2	6,1	1,5	2,6	0,4	1,2		0,8	0,8	0,4	1,0				
111-115	2,8	6,8	6,6	9,3	1,9	3,6		2,4	1,1	0,2	1,6	0,3		0,005	0,5				
116-120	1,9	6,2	6,1	5,7	1,0	1,4		0,3	0,4	0,2					0,1				
121-125	0,5	4,0	4,2	3,8	0,6					0,2					0,03				
126-130	0,8	1,3	2,5	1,7							0,8								
130-135		0,6	1,2	0,3															
135-140		0,1	0,2	0,1															
N			1496	2624	307	362	130	380	263	495	124	941	508	1790	2992	72?	160	205	192



6.7.4.1.2.1. The dynamic of Rapa Whelk biomass in the Kerch Strait, Ukraine.

There are biological studies about rapa whelk in Ukraine including weight-at-length and weight-at-age information for 2003-2008. The age groups ranged between 2-9 years. The minimum length was 61.8 mm and the maximum was 112.0 mm. The minimum and maximum weight values are 44.5 g and 320.0 g in these five years time. The mean lengths for this period (2003-2008) were, 65.63mm, 79.83mm, 74.96mm, 73.66mm, 76.72mm and 80.4 mm and the mean weights were 117.6g, 149.9g, 120.4g, 91.3g, 102.56g and 117.43 g. The age composition of rapa for 2003-2008 is represented in 6.7.4.1.2.2. Ukraine has an age-length key for 2003-2008 that can be used to transform any length-frequency distribution to age (Shlyakhov and Mikhaylyuk, 2010).

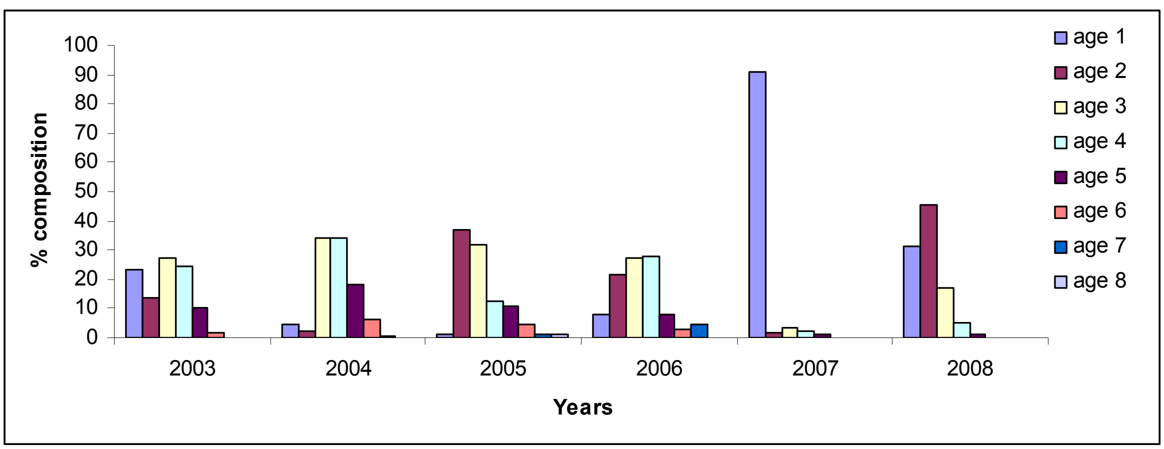


Fig. 6.7.4.1.2.2. The age composition of rapa in Ukraine for 2003-2008.

Distribution of rapa whelk catches by size and age groups during the survey in 1992 (Prodanov et.al, 1995), is given on Figure 6.7.4.1.2.3.

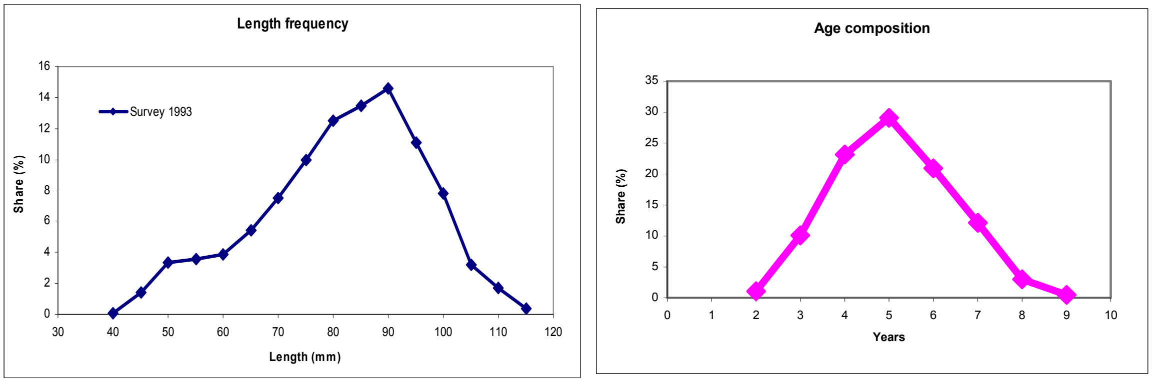


Fig. 6.7.4.1.2.3. Size and age structure of R. venosa in 1992 along the Bulgarian Black Sea coast (after Prodanov et.al, 1995)

The overexploitation of eastern stocks speeds the decline through the ends of 1990s and a significant difference in mean length appears between western (Samsun and Bulgaria) and eastern (Georgia and Ordu) stocks. For example, the mean length is 4.7 cm (1.1-10.7 cm), 6.4 cm (2.5-11.7 cm) and 6.9 cm (3.5-11.9 cm) for eastern stocks, Samsun (Kizilirmak and Yeşilirmak shelf area) and western stocks, respectively (Figure 6.7.4.1.2.4) (Knudsen and Zengin, 2006). Therefore, eastern *Rapana* fishermen move to Samsun area and further west. It is also confirmed by a number of studies that the mean length decreased contrarily to the increase in biomass. The mean length was recorded as 11.0 cm in 1986 (Ünsal, 1989), 6.7 cm in 1991 and 6.5 in 1992 (Düzgüneş et al. 1992) 5.4 cm in 1999 (Emiral, 2003) and 4.5 cm in 2003 (Zengin, 2006) (Figure 6.7.4.1.2.4).

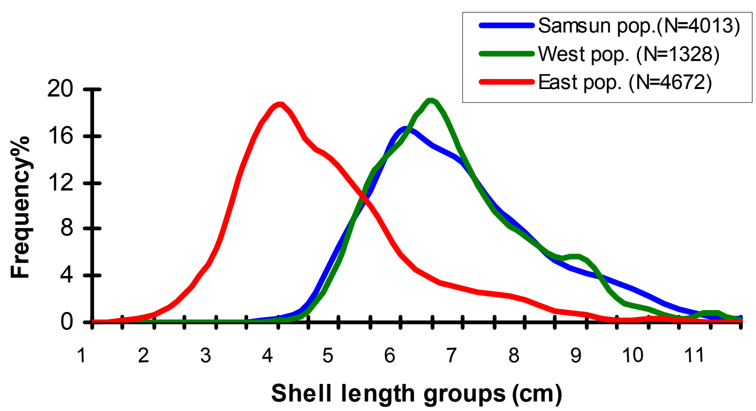


Figure 6.7.4.1.2.4. The length frequency distributions of Rapa whelk caught by commercial dredges in fishing season 2005, along eastern coasts (Georgia-Ordu), Samsun and western coasts (Samsun-Bulgaria),

The possible reasons of the decrease in mean length may be considered due to: (1) The overexploitation of larger length groups due to high demand for market and export. (2) The reduction of natural food sources as a result of intense Rapa predation and consequential poor feeding period.

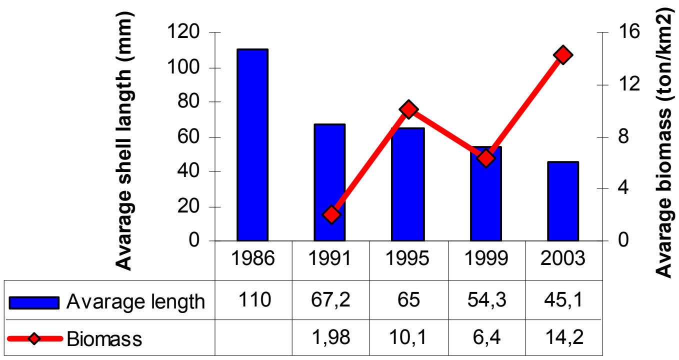


Figure 6.7.4.1.2.4. The relationship between the mean length and biomass of the Rapa whelk in south eastern Black Sea.

Some bio-ecological parameters are estimated during the study carried out on eastern Rapa whelk population along Trabzon coasts (Emiral, 2003). The measured lengths have ranged between 2.0 and 9.5 cm, with mean length of 5.3 cm. The shell width is calculated as 3.7 cm and the mean weight as 27.7 g.

7.7.3 Short term prediction of stock biomass and catch

Given the data available the EWG did not do a short term prediction of stock size and catches under various management options.

7.7.4 Medium term prediction of stock biomass and catch

The WG did not undertake medium term projections.

7.7.5 Long term predictions

Given the data available the EWG did not do a long term prediction to develop biological reference points consistent with high long term yield and low risk of fisheries collapses.

7.7.6 Scientific advice

7.7.6.1 Short term considerations

State of the spawning stock size:
Given the status of the data and assessment the EWG 11-16 is unable to provide scientific advice.

State of recruitment:
Given the status of the data and assessment the EWG 11-16 is unable to provide scientific advice.

State of exploitation:
Given the status of the data and assessment the EWG 11-16 is unable to provide scientific advice.

7.7.6.2 Medium term considerations

Given the status of the data and assessment the EWG 11-16 is unable to provide scientific advice.

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9 APPENDIX 1: EWG-11-16 LIST OF PARTICIPANTS

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10 LIST OF BACKGROUND DOCUMENTS

None

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Abstract
The Scientific, Technical and Economic Committee for Fisheries gave its opinion by written procedure in November 2011 on request by the European Commission. In response to the ToR the STECF EWG 11-16 on Black Sea stock assessments has accomplished seven stock assessments approaches of sprat, turbot, anchovy, whiting, horse mackerel, piked dogfish and rapa whelk. Relevant data have been compiled and reviewed, including those called officially by DG Mare through the 2011 DCF data call for the Mediterranean and Black Sea. Expert knowledge completed the data underlying the stock assessment approaches. The methods and data of the seven stock assessment approaches are documented in section 6 of the present report. For four analytically assessed stocks, i.e. sprat, turbot, anchovy and whiting, fisheries management advice is provided.

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The Scientific, Technical and Economic Committee for Fisheries (STECF) has been established by the European Commission. The STECF is being consulted at regular intervals on matters pertaining to the conservation and management of living aquatic resources, including biological, economic, environmental, social and technical considerations.

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